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GOVERNMENT OF INDIA
MINISTRY OF STEEL AND MINES

COMMITTEE ON ECONOMY IN CONSUMPTION OF STEEL IN THE COUNTRY

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CHAPTER I

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations of the Committee are summarised below under appropriate headings. Figures in brackets refer to the relevant paragraphs in the report.

PART I - FOR IMMEDIATE IMPLEMENTATION

General.

1. The present design methods and types of structures used will require to be modified and use of substitute materials resorted to. The pattern of production of finished steel products will also have to undergo a corresponding change to suit those modified designs and structures. If these two processes do not go side by side, any effort made solely by the users will not produce perceptible results in reduction in consumption of steel. (5.0)

2. The extra expenditure involved in importing steel at a high cost could with advantage be used for capital investment for changing the pattern of production of finished steel products in the existing steel plants and for setting up additional steel plants for manufacture of steel products, which otherwise are being imported now. (5.0)

3. Concentration will have to be on the efficient use of bars, rods, plates, sheets and structurals, as they form nearly 2/3rds of the total production in the country.(5.0.1)

4. Use of high strength deformed bars instead of plain bars as main reinforcement in RC and adoption of improved methods of design will conserve about 0.25 million tonnes of reinforcement steel per annum which will make it possible to undertake 33.33 per cent extra constructional work in RC. (5.0.2)

5. RC and PC structures require much less steel as compared to steel structures. It is, therefore, imperative that the adoption of steel structures be restricted strictly to those cases where RC or PC is not technically feasible. Substitution of steel structures by RC/PC may result in about 50 to 70 per cent saving of steel. (5.0.3)

Residential and office buildings.

6. Where good bricks are available, load bearing masonry structures without RC columns and beams may be provided in low rise buildings, say upto 4 storeys, depending upon the strength of bricks. In the case of office buildings

where larger rooms are required, a combination of RC frames and load bearing walls may be adopted, if necessary. (5.1.1)

7. Where adoption of framed structures for multi-storeyed buildings is unavoidable, this may be of RC construction generally. Where buildings have a large service core to serve as a stiff shear wall, combination of RC frames and shear walls may be used. In other cases, "framed tube", "tube-in-tube" and "bundled-tube" systems may be suitable depending upon the height of the buildings. (5.1.2)

8. In tall residential buildings (say about 12 storeys and above), such as apartments, hostels, etc., where the walls are located directly one above the other, considerable economy can be effected by providing nominally reinforced concrete load bearing walls instead of a framed structure. It may be necessary for C.P.W.D. to examine the thermal insulation of the walls in Indian conditions based on a study of the buildings already constructed in the country. If this examination proves their suitability for local conditions, there will be need to popularise this technique. (5.1.3)

9. Use of brick partition walls in multi-storeyed buildings may be avoided and light weight cellular concrete blocks used instead, as far as possible, in cities where the latter are being manufactured. In other places also the use of brick filler walls should be minimised and other types of light weight partitions, such as particle boards should be used, wherever possible. (5.1.4)

10. Wherever RC slabs are provided, the design may be based either on yield line theory or Hillerborg's strip method (modified) to derive the benefits of economy in consumption of steel. (5.1.5)

11. Use of precast flooring/roofing units such as trough units, cellular units, doubly curved shell units and hollow clay blocks result in economy in steel compared to conventional RC slab construction, even if designed on yield line theory. Significant savings are achieved when the shorter side of the room to be covered is more than about 3.5m. Their use, in preference to cast-in-situ RC slabs is, therefore, recommended in mass housing schemes undertaken by different State Housing Boards and government organisations initially, to be followed later by public as well. (5.1.6)

12. Jack arches with RC supporting beams are recommended for adoption in floors and roofs of buildings with load bearing walls, in lieu of RC beam and slab construction, as far as possible. (5.1.7)

Industrial structures, storage sheds and other similar structures.

13. At present, a majority of industrial structures, storage sheds and similar structures are of conventional designs with steel columns treated as propped or free vertical cantilevers and simply supported roof trusses. This type of construction may be avoided. Instead they can be planned either as completely RC structures or partly RC and partly steel constructions. Even in industrial structures with cranes of upto medium capacity RC columns may be used instead of steel, leading to economy in consumption of steel. (5.2 and 5.2.5)

14. All structures may be constructed, as far as possible, only as RC rigid frames with deformed bars as main reinforcement. Till such time deformed bars become available in requisite quantity, mild steel plain round bars may be used. (5.2.1)

15. Shell and folded plate structures consume minimum amount of cement and steel compared to any form of RC construction. These will be suitable only if a large number of identical units are to be constructed. Large workshop structures where this condition is fulfilled may be constructed as doubly curved shells, such as hyperbolic paraboloid, conoid and hyperboloid shapes which can be cast on forms composed of straight planks, being ruled surfaces. (5.2.2)

16. Precast and prestressed corrugated shells, funicular shells and hyperboloid shells and PC trusses may be used for storage sheds replacing steel structures. Prestressed shell elements may be prestressed in the longitudinal direction as well for connecting them. A saving of steel upto 50 per cent can be expected with these systems. These may be standardised by I.S.I. in consultation with S.E.R.C. and suitable design aids furnished to the users. Standardisation will help the industry to manufacture the precast products and make available as ready-made units in the country. (5.2.3)

17. Funicular shells with bricks are suitable for use in storage sheds and industrial buildings without crane loading. N.B.O. may, in consultation with S.E.R.C., publish literature on the subject for its large-scale adoption. (5.2.4)

18. 1,00,000 tonnes of C.G.I. sheets are used per annum which, besides involving wasteful use of steel, also requires imported zinc for galvanising. It is, therefore, necessary to restrict its use and adopt substitute

materials such as AC sheets and asphaltic corrugated sheets. This will release the capacity in steel plants for making plates or strips which are in short supply in the country. (5.2.6)

19. Since asbestos fibre is to be imported, the urgency of discovering asbestos fibre in the country needs no stressing. The work done by C.B.R.I. for manufacturing AC sheets using indigenous asbestos fibre has to be pursued for its further development. As a more realistic measure, however, for achieving early results, it might be desirable to aim at development of a partial or full substitute for asbestos fibre. (5.2.6)

20. Asphaltic corrugated sheets have better thermal insulation and are comparatively cheap. They may be used for temporary and permanent buildings, sloping roofs in coastal areas and hill stations and as roof for rural housing and also in industrial buildings, wherever possible. (5.2.6)

21. Only in those cases where the methods mentioned above are not feasible, structures made of new steel may be resorted to. In all such cases welded construction instead of riveting should be the normal practice and the structures designed as rigid frames by plastic theory where possible. In industrial buildings with overhead cranes, where designs cannot be based on plastic theory, it is recommended that welded rigid frame structures designed on elastic theory may be adopted. In these cases also use of tubular/hollow sections has to be preferred to that of plates and structurals. If used for heavy construction, the field connections could be welded or with friction grip fasteners. Use of light gauge structurals in preference to rolled structural sections is recommended only where the use of tubular sections is not feasible.

Open web structures of either tubes or angles and bars, open web joists with concrete flange and castellated beams can be used as long span purline, roof trusses in medium span storage buildings and in lightly loaded locations. I.S.I. may standardise these systems in consultation with S.E.R.C. (5.2.7 to 5.2.10)

22. I.S.I. Handbook on tubular construction now in the formulation stage may be published early. (5.2.8)

Platform shelters and foot-overbridges in railways.

23. Use of structural steel in these structures should be avoided as far as possible. PC/RC either of precast elements or cast-in-situ may be used in lieu. Use of shell roofs for platform shelters will result in considerable saving in steel but they may be suitable only in locations

where a large number of identical units are constructed. Where use of structural steel is unavoidable, tubular sections may be used in lieu of rods and structurals, where possible. (5.3)

Highway bridges.

24. Standard designs for segmental arch bridges in plain concrete for spans upto 12m issued by the Ministry of Transport may be adopted to the maximum extent possible in all road bridges to be constructed by State Governments and local bodies. (5.4.1)

25. RC pipes could be adopted instead of abutments and slabs for culverts of 1.5m span and below. (5.4.1)

26. In longer span bridges, the girders shall as far as possible be of PC and Ministry of Transport might consider standardisation of PC girders for adoption by all State Governments. Where RC work is involved the main reinforcement may be of high strength deformed bars to the extent possible. (5.4.1)

Railway bridges.

27. Short span bridges upto 6m may be of precast prestressed concrete slabs instead of RC slabs or T-beams, at present in use. (5.4.2)

28. For spans upto 25m PC girders may substitute steel girders, in new constructions and in doublings. These are being standardised. (5.4.2)

29. In MG-BG conversions, released MG steel girders may be strengthened and re-used for BG loading, wherever this does not present problems and existing material is of a quality suitable for strengthening and retention. (5.4.2)

Water supply installations.

30. PVC and AC pipes may be used substituting steel pipes upto a dia of 315 mm. It is necessary to develop an efficient and effective method of joining PVC pipes. The I.S.I. may take urgent action to finalise the codes for PVC pipe fittings and their laying and jointing. Rate contracts may be concluded by the DGS&D and suitable instructions issued by government organisations for their adoption. (5.5.1 and 5.5.2).

31. PC and RC pipes may be used replacing large diameter pipes. ISI can standardise these products in consultation with the Ministry of Works and Housing and C.P.H.E.R.I/Nagpur. (5.5.2)

32. Water tanks and stagings may, as far as possible, be constructed of RC with high strength deformed bars as main reinforcement. Use of RC tanks may not, however, be practicable in railway yards, where these tanks might have to be dismantled and shifted to provide for any future yard re-modelling required. (5.5.3)

Steel production.

33. Stepping up production of high strength deformed bars from the present level of 2.12 lakh tonnes to at least 1 million tonnes as early as possible is one of the most important steps in the steel saving. Steps required to achieve this objective are :

(a) Bulk, say 70 per cent, of the production of MS round bars in the range 8 mm to 40 mm may be as cold twisted deformed bars to IS:1786.

(b) I.S.I. may circulate immediately to all producers and re-rollers modified chemical composition of blooms and billets, as per amendment finalised recently.

(c) The best way to avoid unscrupulous and unauthorised production of substandard material would be to insist on I.S.I's Certification Mark for the deformed bars produced.

(d) The government should be more liberal in allowing collaboration for manufacture of deformed bars or persuade TISCO to extend their know-how to all those parties who can take up manufacture of deformed bars. This should, of course, be with the proviso that there will be no recurring foreign exchange requirements.

(e) While on the one hand emphasis is on better quality of steel with higher strength, anomaly exists in the government policy that a large number of existing electric furnace units are not permitted to produce any steel other than mild steel. The Committee is of the view that such a restriction may be self-defeating.

(f) High strength deformed bars with a proof stress of 50 kg/sq.mm are being produced in the country. Increase in its production may be encouraged.

(g) It is possible for B.S.P. to develop within a year cold rolled deformed bars with a proof stress of 55 kg/sq.mm., with installation of some plants and equipments. If the finished steel product can be sold at the same rate as that of cold twisted bars, manufacture of these bars in BSP is recommended. (5.6.1 and 5.0.2)

34. Non-availability or inadequate availability of HTS wires may pose one of the major bottlenecks in the substitution by PC for various usages. This is traced to inadequate availability of medium and high carbon wire rods, which are not capable of being produced by the ordinary mild steel re-rollers. The government may take necessary steps to augment adequately the capacity for production of medium and high carbon wire rods in the country and this should not be difficult with a number of electric furnaces coming up. (5.6.2)

35. The present output of plates to IS:226 will have to be increased to enable adoption of welded construction on a large-scale in non-dynamically loaded structures. (5.6.3 and 5.0.3).

36. Stepping up the production of cold formed light gauge structurals including larger diameter tubes is essential. Skelp and strips required for the purpose may be produced in sufficient quantities. Steel plants may also examine the possibility of manufacture of hollow sections. (5.6.4 and 5.0.3)

37. Where re-rollers have spare capacity, hot rolled deformed bars for reinforcement may be manufactured from scrap rails and axles. Railways have already issued specifications for rolling plain bars and are considering manufacture of deformed bars as well. I.S.I. can formulate a specification for the purpose on the lines of ASTM specifications, adopting the Railways' practice. (5.6.5)

38. Light beam and light channel sections standardised by I.S.I. are more efficient in use of steel than medium and heavy sections. 4 ISLB and 4 ISLC sections were recommended for rationalisation by the Wanchoo Committee. There is an urgent need for JPC to act upon these recommendations. Relaxations in the thickness of the web and the flange asked for by the producers have already been incorporated in I.S. specifications. (5.6.6)

39. Proposals of BSP to go in for production of "nearly parallel" flange beam sections require to be encouraged. Suitable standards to cover these products may be prepared by I.S.I. and J.P.C. may arrange to have them included in the list of rationalised sections. (5.6.7)

40. J.P.C. may not recognise or publish prices for sale of offgrade quality structurals and plates. (5.6.8)

41. Steel mills may produce generally structurals and plates to I.S. specifications only for sale within the country. In the interim period till sale of offgrade structurals and plates stops, suitable colour code may be introduced to distinguish between offgrade material and the material to standard specifications. These restrictions will not be applicable to semi-finished steel goods, such as billets which could all get covered, probably, under the specification IS:1570-61. (5.6.8)

Production of cement.

42. The implementation of the recommendations will mean that consumption of cement will increase to some extent. With the increase in production of cement being planned in the country, making available this additional quantity of cement, it is expected, may not present a serious problem.(5.7)

Production of bricks.

43. The brick industry should be brought partially under the purview of the organised sector for scientific development, particularly in big cities. (5.8)

44. Proposals to set up mechanised brick plants in Hyderabad, Bombay, Jammu, Bhuvaneshwar, Chandigarh, Vishakapatnam, Gauhati and Delhi and sand-lime brick plants at Indore, Hoshangabad, Jaipur, Nagpur and Hyderabad require to be pursued to be followed by setting up more such plants in other major cities. This may be arranged by the Ministry of Works and Housing in collaboration with State PWDs and Ministry of Industrial Development. (5.8)

Production of cellular blocks.

45. Proposals to set up plants for production of cellular blocks at Bandel, Badarpur, Bhatinda, Kanpur and Bombay need to be pursued. There is scope for setting up a number of such units adjacent to thermal power plants where fly ash becomes available as a waste product and these may be installed at least near the areas where multi-storeyed constructions are coming into prominence. (5.9)

Production of asphaltic corrugated sheets.

46. Progress on setting up of plants for production of asphaltic corrugated sheets in HP, UP and Maharashtra may be accelerated. (5.10)

Production of welding equipment and consumables.

47. Manufacture of suitable welding equipment indigenously

and stepping up production of welding consumables needs no emphasis. (5.11)

48. The delay in supply of welding rods, after their manufacture could be cut down, if the excise duty is fixed on weight basis or on length basis instead of the present method of fixing it as a percentage of the value (ad valorem). (5.11)

Codes and specifications.

49. I.S.I. may undertake an urgent review of its design codes for increasing the permissible stresses in steel, reduction in load factors, downward revision in the standards for superimposed and wind loads and also for reducing the lap lengths prescribed for deformed bars. (5.12).

50. I.S.I. may also consider prescribing provisions in the code for redistribution of moments in RC rigid frames in addition to continuous beams and slabs, taking into consideration the latest provisions in British, American, Russian and other codes. IS:456 may have to provide for design of two-way slab on Hillerborg's strip method (modified) as well. (5.12)

51. I.S.I. Code on structural use of aluminium now in formulation stage may be finalised and issued early. (5.12)

Assessment of overall savings.

52. In view of a number of variables involved, it is practically difficult to estimate with any degree of accuracy the overall saving in quantity that can be achieved. A rough assessment made, even on a very modest rate of percentage saving shows that a reduction in consumption to the extent of about 0.47 million tonnes of steel per annum, with reference to the present level of consumption and production in the country, can be anticipated, if all the above recommendations in respect of civil engineering works are fully implemented. (5.13.1)

53. Various short-term proposals have been made by the Committee after taking into consideration the practical aspects of their implementation within a short time, and for this purpose, the period for implementation has been assumed to be about 5 years. In the first 2 or 3 years, the saving will naturally be less than what has been indicated, in view of the fact that various measures would be in different stages of implementation and only some would have been fully implemented. (5.13.2)

Additional investigations.

54. The recommendations are mostly pertaining to civil engineering works. The Committee could not go into details of consumption pattern in other industries (except design and manufacture of railway wagons and coaches) and of alloy, special and tool steels. It is considered that there is scope for optimising production and use in these fields as well. Instituting separate investigation for the purpose may be justified. (5.13.3)

55. Out of 10.54 lakh tonnes of mild steel imported in 1971-72, 7.64 lakh tonnes comprised mild steel plates and sheets. Railways requirements accounted for only 74,700 tonnes. The Committee could not get the full details of the bulk users of the remaining major quantity of plates and sheets imported. It would appear necessary to identify all the industries using imported steel and decide on suitable measures to be taken to reduce consumption of plates and sheets therein. The Committee recommends investigation to be undertaken immediately. (4.2)

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PART II - FOR LONG-TERM IMPLEMENTATION

General.

56. The recommendations given under "Part-I - For immediate implementation" should be continued on a long-term basis as well. (6.0.1)

57. With regard to the recommendations for long-term implementation, action should be initiated immediately. Results of economy can, however, be felt only after a considerable lapse of time. (6.0.1)

58. Reduction in consumption of steel and other building materials and consequent reduction in total cost of works may be achieved, if the latest techniques in structural optimisation are applied. (6.0.2).

59. Thorough planning including detailing of steel components to minute detail will enable correct sizes and lengths of components to be ordered wherever possible, eliminating wastage. Where low grade material would serve the purpose of strength and durability that could be used in preference to steel. Even between one grade of steel and another, where a lower grade would suffice, use of that may be insisted upon. (6.0.3)

Residential and office buildings.

60. Use of high strength deformed bars of proof stress upto 90 kg/sq.mm. can lead to significant saving in steel. It would, however, suffice if high strength deformed bars of proof stress upto 60 kg/sq.mm. are developed, provided there is no recurring expenditure in foreign exchange involved in import of additives, however marginal and small the quantity may be. (6.1.1)

61. Reduction in dead load of the structural members of framed multi-storeyed buildings by use of light weight structural concrete will result in 10 to 15 per cent saving in steel. Manufacture of light weight aggregate made out of expanded clay is to be developed on a priority basis. This is also more useful in Gangetic plain where the availability of stone aggregate is poor. Reinforced light weight cellular concrete slabs may also be made use of as an alternative to light weight structural concrete where suitable, although the thickness will have to be increased in such cases. (6.1.2)

62. Although it is premature to think of large-scale use of fibre glass for reinforcement in concrete, need for its development exists. (6.1.3)

63. Timber can be utilised for a large number of structural uses where at present steel is being demanded. Expensive higher grades of timber could be reserved for permanent structures while in the case of rural houses, temporary and semi-permanent buildings, buildings in hill areas and high altitudes, low cost houses in urban areas, etc., less expensive secondary species of timber, the durability of which could be improved by processing, may be utilised. Necessary I.S. codes for design are already available. Utilisation of small dimension stock and development of glued laminated wood, timber connectors, etc., are yet to make much headway. (6.1.4)

64. Frame analysis for RC structures should be based on limit state analysis and incorporation of suitable provisions in codes and preparation of design aids may be undertaken by I.S.I. in collaboration with S.E.R.C. (6.1.5)

65. There is scope for reduction in the quantity of reinforcement of steel if welding is adopted instead of lapping. I.S.I. may finalise the procedure to be followed and precautions to be taken for welding cold twisted high strength bars of indigenous manufacture and issue an amendment to IS:456 based on investigations to be done by independent organisations like S.E.R.C , R.D.S.O., etc. S.E.R.C. may take action regarding the assessment of suitability of high strength deformed bars using alloy elements and give suitable recommendations for incorporation in I.S. code (6.1.6)

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Structures.

66. For situations where steel structures are unavoidable, economy in consumption may be achieved by the following methods:

(a) Use of weather resistant steel in preference to HTS to IS:961-62 is recommended for use in very tall towers for microwave and television antennae, in framed structures effectively braced laterally and in multi-storeyed steel frames, when used.

(b) Use of welded box girders may be made in girders and columns in medium and heavy industrial buildings. (6.2.1 to 6.2.3)

67. Extensive service trials for reasonable periods with PC/tubular structures for railway electrification masts may be undertaken and if the trials prove successful, they may be adopted. (6.2.4)

68. About 45 to 50 per cent of structural steel used in steel plant structures is consumed in crane gantry girders and columns. Any reduction in design loads will result in considerable economy in steel. The present provisions in the I.S. codes for impact, surge and longitudinal loads to be considered in the design of crane gantry girders and columns may need modification. Metallurgical and Engineering Consultants (India) Limited may arrange for investigations to be conducted to arrive at the realistic values for these loads, compare with the practices followed in other countries and furnish necessary data to I.S.I. for revision of the codes. (6.2.5)

Highway bridges.

69. Use of PC girders in road bridges upto 160m may be considered by the Ministry of Transport. In still longer spans, use of light weight structural concrete prestressed or very high strength concrete (with concrete-polymer composites) may be thought of. (6.3.1)

70. Welded steel box girders have a great potential for use in highway bridges in spans even upto 1000m. Ministry of Transport may consider their adoption in long span bridges. (6.3.2)

71. Large scale use of cable stayed girders may be considered when high strength steel plates, structurals and cables become available in the country and facilities for welding and inspection improve. (6.3.3)

Railway bridges.

72. PC girders may be adopted for spans upto 46m in new constructions and doublings. Suitable designs for precast elements for PC girders may be evolved so that these girders can be used for regirdering of existing bridges. (6.4.7)

73. Box girders of PC may also be adopted in longer spans to achieve minimum use of steel. They are eminently suited for ballasted viaducts and elevated structures for Metropolitan Transport Projects (Railways) which are due to come in future. (6.4.7)

74. Railways may expedite their proposed studies on fatigue behaviour of RC with indigenously manufactured deformed bars and take action for increasing the permissible stresses in deformed bars in designs of railway bridges. (6.4.8)

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75. Where PC/RC cannot be adopted, the following measures are recommended:

(a) Use of copper bearing quality H.T.S. to IS:961-62 may be adopted in long span open web girders as a standard practice in routes where speeds in excess of 160 km/h are not contemplated. (6.4.1)

(b) Weather resistant steel, if it becomes available in the country may be made use of for plate girders and open web girders. (6.4.2)

(c) Welded girders of steel to IS:2062-69 may be used. Necessary facilities may be developed in workshops along with installation of adequate radiographic inspection equipment. (6.4.3)

(d) Use of welded box girders, orthotropic plate construction and continuous girders will result in further economy of steel and railways may develop expertise in these fields. (6.4.4 to 6.4.6)

76. Although use of aluminium alloys have a potential for application in railway bridges in certain conditions, their use is only a distant possibility when the country produces sufficient quantity of structural grade aluminium alloys. (6.4.9)

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Railway track.

77. Elimination of rail joints by welding goes a long way in increasing the service life of rails and Indian Railways propose to lay long welded rails/continuous welded rails on their hard core routes totalling to about 25,000 km track, which will bring about an annual saving of about 27,500 tonnes of rails. (6.5.1.5)

78. Reconditioning of points and crossings in-situ by repair welding on a large scale will bring down its consumption by 5,000 tonnes per annum. Use of cast manganese steel crossings will save another 1,000 tonnes of rails per annum. (6.5.1.6)

79. Re-use of released rails by techniques which include ultrasonic testing, end cropping, welding to form long rails and finally re-profiling to get correct table top and gauge face, if practised can permit 50 per cent of the rails released to be re-used. Installation of ultrasonic testing devices and rail re-profiling machine is suggested along with a techno-economic study of the process. (6.5.1.7).

80. With progressive introduction of welding of rail joints, the demand for fishplates and fishbolts would be substantially reduced. Use of smaller diameter bolts and nuts now on trial if proves successful, will also result in sizeable economy. (6.5.2)

81. Scrap fishplates, tie-bars, screw spikes, etc., can be reclaimed and re-used by repressing of fishplate, conversion of BG tie-bars into MG ones and forging and re-threading of screw spikes. Released steel trough sleepers from BG can be cut, repaired and re-used in MG (6.5.2.1)

82. It has been decided by the Railway Board to use prestressed concrete sleepers on all the important trunk routes of the Broad Gauge with a kilometrage of about 25,000. Although as a short-term measure, no significant economy in the consumption of steel in sleepers will be possible, with the use of prestressed concrete sleepers, there will be substantial saving to the extent of 42,000 tonnes of mild steel and 64,000 tonnes of cast iron at a stage when the production of prestressed concrete sleepers in the country reaches the 1.5 million mark. Use of RC two-block sleepers involves increased consumption of steel and their use may not be advantageous. (6.5.3)

Railway wagons.

83. Welded fabrication is lighter compared to riveted fabrication and the change over from riveted to welded construction has to be effected gradually. (6.6.1)

84. Designing wagons for the transport of specific commodities would permit the optimum design being evolved leading to the use of minimum quantity of steel. (6.6.2)

85. With the adoption of centre buffer couplers as a standard, the need for fitment of side buffers and diagonals would cease leading to a saving in consumption of steel. For this, indigenous capacity for manufacture of steel castings is to be augmented. (6.6.3)

86. In riveted designs, use of pressed sections instead of rolled sections will lead to economy in steel. (6.6.4)

87. Use of low alloy high yield steels for wagon construction could lead to a saving of nearly 10 per cent in the consumption of steel. This could also be used for 'patches' put on and structurals replaced during repairs. This special quality steel has to be developed and manufactured. (6.6.5)

88. It is not opportune to consider use of aluminium for wagon construction. (6.6.6)

89. Use of fibre glass reinforced plastic for barrels of tank wagons is not considered suitable in India at present when efficient mechanical retarders are not installed in all the hump yards. (6.6.7)

90. Rubber is used in side buffers in lieu of helical springs already. Use of rubber springs in lieu of steel springs at other places would have to pend till the indigenous development of such a material. (6.6.8)

91. Cast steel bogies would lead to reduction in consumption of steel and this has already been adopted as standard for bogie stock on Indian Railways. (6.6.9)

Railway coaches.

92. With the introduction of longer coaches and double deck coaches, there will be substantial reduction in the quantity of steel used for coach construction. These designs have been developed and are proposed to be tried. (6.7.1)

93. A number of steel fittings in coaches could be replaced by fibre glass reinforced plastic and plastic items. (6.7.2)

94. Development of aluminium coaches is expected to take about 5 to 7 years and with their introduction, substantial saving in steel can be achieved, subject to availability of aluminium. (6.7.3)

95. For obtaining optimum service life of suspension springs, they are to be manufactured out of peeled and centreless ground steel rods, facilities for which are to be developed. (6.7.4)

96. It is desirable to use low alloy high tensile steel for coach construction, which will have in-built corrosion resistant properties. A design of centre-sill type has been evolved in R.D.S.O. and prototype production and stress exploration tests planned. This design in conjunction with use of low alloy high tensile steel is expected to result in considerable saving in steel used for repair works. (6.7.5)

97. Creation of facilities for production of tyres and wheels with better wear resisting properties can bring about some reduction in consumption of steel. Their effect on rails will also have to be assessed. (6.7.6)

Improved maintenance practices.

98. In important structures, bridge girders and wagons, better surface preparation with grit/sand blasting for the cleaning of the surfaces shall be followed as far as possible. It would be necessary to augment the indigenous capacity for manufacture of the blasting equipment required and the steel grit. (6.8.1)

99. Use of better painting systems in lieu of red lead which requires import should be adopted for structures in non-coastal regions. For the coastal regions, metallising with aluminium followed by painting is recommended. (6.8.2 and 6.8.3)

100. Galvanising as a general practice is not recommended, to restrict import of zinc. (6.8.4)

Reuse of scrap axles and worn out tyres.

101. Scrap axles, metallurgically sound, can advantageously be re-used for manufacture of a number of locomotive, wagon and coach components. Scrap carriage and wagon tyres can be used for spring steel flats and hand tools. The above measures are already in vogue in Railways.(6.9)

Some experimental work has been carried out by the Railways for building up the worn out portions on carriage and wagon tyres using submerged arc process. Necessary investigations for standardisation of the technique are being taken up. (6.9)

Production of steel.

102. Wear resistant rails to UIC grades 'A' and 'B' with a minimum UTS of 90 kg/sq.mm. are weldable and have a greater potential for use in trunk routes and main lines. Their development and production is recommended. Development of chrome manganese rail, if comparatively easier, is also recommended in preference to those of UIC grade 'C' rails. Development, for the present, of Hadfield manganese steel rails is not advisable. (6.5.1.1 and 6.10.9).

103. It is necessary to investigate the possibility of developing a suitable alloy steel to resist corrosion effectively for use in about 1,600 km of track which falls in corrosive areas requiring frequent rail renewals. (6.5.1.2 and 6.10.9).

104. There is need for investigations to be initiated to establish the techno-economic viability of developing and producing volume hardened and tempered rails. (6.5.1.3 and 6.10.9).

105. Development of all the crane rail sections shown in IS:3443-66 is desirable in the interest of conserving foreign exchange, although the quantity of crane rails consumed in the country may not be considerable. (6.10.10)

106. For achieving maximum economy in consumption of steel it would be necessary to develop facilities in the country for production in adequate quantity of plates and structurals of killed quality steel to IS:2062-69, high strength deformed bars of proof stress upto 60 kg/sq.mm. (hot or cold rolled), copper bearing HTS to IS:961-62, weathering steel, low alloy high strength steel of weldable quality and very HTS of weldable quality having proof stress of 70 to 80 kg/sq.mm. (6.10.1)

107. Facilities for manufacture of parallel flange beams have to be planned immediately so that in course of a few years a complete switch over to manufacture of these sections would be possible. Installation of universal mills in new steel plants will have to be a part of this programme (6.10.2).

108. I.S.I. may prepare necessary standards for parallel flange sections on the lines of I.S.O. standards. (6.10.2)

109. It is necessary for the Steel Ministry to pursue the project of setting up of six plants for automatic fabrication of continuously welded beams of depth upto 2m, recommended by Wanchoo Committee, when the country becomes self-sufficient in plates to IS:2062-69. (6.10.3)

110. There are a few rationalised structural sections which are not to any Indian Standards. If they are found efficient in use of steel they may be incorporated in Indian Standard; otherwise their manufacture may be stopped. (6.10.4)

111. Producers shall arrange to roll to start with at least all the rationalised I.S. sections. In course of time, the number of rationalised sections may increase progressively to cover all the I.S. sections. A periodical review may be undertaken by J.P.C. for the purpose in consultation with I.S.I. and major users. (6.10.4).

112. Efforts may be made by steel plants to supply plates in lengths upto 13.5m to meet the special requirements of railways and other organisations, as otherwise there will be wasteful use in providing splice joints, particularly in riveted structures. (6.10.5)

113. Sophisticated automatic hot/cold sawing equipment may be progressively introduced in steel plants and fine cutting tolerances of +3mm and -0 in lengths of finished steel products may be obtained. (6.10.6)

114. Yield of continuous cast steel is about 90 to 96 per cent compared to 70 to 75 per cent with the conventional steel making process. Increased use of continuous casting will lead to higher production. (6.10.7)

115. Oil quenching and tempering facilities for wheel tyres may be set up which measure will reduce the requirement of tyres for steam locos and EMU coaches in the long run. (6.10.8)

Timber production and distribution.

116. Although wood seasoning and treatment plants have been set up in various parts, concomitant developments required for supply of timber and scientific methods of conversion and utilisation of timbers from logs are yet to come to satisfactory levels. Corporations for processing and marketing timber have been formed only in some states such as Orissa, Madhya Pradesh, Rajasthan, Maharashtra and Karnataka. It is recommended that the remaining states also may consider setting up corporations so that technically acceptable material both of the primary and secondary species may be made available everywhere. (6.11)

117. Ministry of Industrial Development may undertake a detailed study for development and production of light weight aggregates made out of expanded clay, concrete-polymer composite, fibre glass, structural aluminium alloy, high strength cables, rubber springs, etc. Setting up of light weight aggregate plants proposed at Calcutta, Lucknow and in Tripura requires to be pursued. (6.12).

Extent of savings.

118. A rough assessment made assuming a modest percentage of saving reveals that an additional saving to the tune of 2,80,000 tonnes per annum at the present level of consumption can be anticipated with the full implementation of all the long-term proposals mentioned above. (6.13)

PART III - SUGGESTIONS FOR IMPLEMENTATION OF RECOMMENDATIONS

119. Extent of non-implementation of the recommendations that emanated from studies made earlier by certain Committees/ organisations are summarised in para 3.7. One of the main reasons that could be attributed to non-implementation of even some of the most important recommendations has been the absence of a separate organisation or machinery having been set up to coordinate with the Ministries and watch and pursue the progress of their implementation. It cannot also be denied that reduction in consumption of steel was greatly hampered due to steel plants having not changed their pattern of production to suit the requirements of the country, with economy in consumption of steel as the objective. (3.7 and 7.0)

120. The existing controlling and regulatory bodies in Central and State Governments and local bodies should undertake the responsibility of ensuring that the recommendations of this Committee are given effect to. It is possible that in some cases, the existing machinery is either not competent or is not adequate to ensure this. In such cases, it is worthwhile strengthening the set up to make it competent and adequate. (7.0)

121. It is emphasized that the existing manufacturers of steel, designers, fabricators and users should be made aware of the national importance of avoiding improper use of and misuse of steel of which there is short supply in the country. Two to three hundred crores of rupees are spent annually in foreign exchange for import of steel. By avoiding this foreign exchange outgo, it may be possible to set up a new steel plant every year in the country. (7.0)

122. The Committee recommends setting up of a Steel Economy Cell that will report to and work directly under the Minister of Steel and Mines. This Cell should be headed by a competent person who has extensive experience of use of steel. The scope of work of this Cell is enumerated in para 7.1. The function of this Cell will be purely one of monitoring the extent of implementation and keeping the Minister of Steel and Mines advised periodically. (7.0 and 7.1)

123. Instructions may be issued by different departments of Central and State Governments adopting the recommendations of the Committee and permitting any increase in cost of work that may result due to implementation of the proposals for economy in consumption of steel. (7.2 and 7.6)

124. Central and State Governments may issue instructions for amendment of bye-laws of Municipal corporations

and Municipalities in line with the recommendations of this Committee. (7.2)

125. Officers and staff manning the bridge and structural design wings in Central and State Governments should be encouraged to undergo refresher courses and specialised in-service training to make them uptodate in modern concepts of design of bridge and structures. (7.2)

126. The departments of Central and State Governments and other administrations responsible for constructional activities and for their approval may, as far as possible, adopt the I.S. design codes for buildings and structures without any relaxation, unless special circumstances warrant such deviation. (7.2)

127. A special Cell may be set up in I.S.I. to prepare and supply, free of cost hand books and design aids to practising civil engineers, architects and final-year civil engineering students in all Engineering Colleges. This Cell will have specialists drawn on deputation from different Ministries and Public and Private Sectors. Unless preparation of handbooks and design aids is entrusted as a whole time job to specialists the work is likely to be delayed. This Cell will also arrange for special lectures to be delivered in engineering colleges to make teachers and students aware of the latest changes in the design codes. (7.3)

128. Institutions, structural designers, research scholars, scientists, manufacturing units, etc., who have done outstanding work and made significant contribution in regard to economy in consumption of steel may be considered for national awards and titles. (7.5)

129. Certificate that the requirement of steel has been kept to the minimum and that the recommendations of the Committee have been fully complied with, may be recorded by the Municipal Engineer in regard to each work to be approved by him and by the officer competent to sanction the estimate in case of each government work. (7.4)

130. The overall expenditure in implementing the recommendations of the Committee will be amply compensated by saving in steel and reduction in import of steel. (7.7)

131. Steel Economy Committees may be constituted by the Government of India periodically, say once in 5 years or so, to review the extent of implementation of the recommendations of the earlier Committee and the benefits therefrom and also to bring the earlier recommendations upto-date taking into consideration the latest concepts in rational and efficient use of steel and their production. (7.8)

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CHAPTER 1.

PREAMBLE

2.1 Shri T.A. Pai, Minister of Steel and Mines was deeply concerned with the demand for steel continually overtaking steel production in the country, and with the consequent outgo of considerable foreign exchange for importing essential steel to bridge the gap. He recognised that the position could be improved by taking suitable steps to make the utilisation of steel proper and more efficient and by modifying the patterns of production to the extent feasible. It was entirely on his initiative that the Government of India in the Ministry of Steel and Mines (Department of Steel) in their Notification No. SC(1)-101(15)/73 dated 17-11-1973 appointed a Committee consisting of the following to make recommendations for economising consumption of steel in the country:

(1)	Shri M. Srinivasan, Director ~~General~~, Research, Designs and Standards Organisation, Ministry of Railways, Lucknow.	**- Chairman.**
(2)	Shri Hari Bhushan, Formerly Chief Technical Adviser, Ministry of Steel and now Adviser (Technical), Ministry of Heavy Industry.	- Member.
(3)	Shri B.S. Krishnamachar, Deputy Director General, Indian Standards Institution.	- Member.
(4)	Shri D.S. Desai Director, M/s M.N. Dastur and Co.(P) Ltd., Calcutta.	- Member.
(5)	Shri J. Mukand, Chief Engineer, Central Design Organisation, Central Public Works Department, Ministry of Works and Housing.	- Member.
(6)	Shri B.B. Rau, Adviser, Public Health and Environmental Engineering, Ministry of Works and Housing.	- Member.

(7) Dr. S.R. Pramanik, - Member.
Formerly Chief Metallurgical Adviser,
Central Engineering and Design Bureau,
Hindustan Steel Ltd., Ranchi.
Now Dy. Chief Engineer,
Metallurgical and Engineering
Consultants (India) Ltd.,
Ranchi.

(8) Shri Samarapungavan, - Member.
Assistant General Superintendent,
Bhilai Steel Plant,
Bhilai.

(9) Shri Kalicharan, - Member Secretary.
Director, Civil Engineering,
Railway Board,
Ministry of Railways,
New Delhi.

This notification also mentioned that the Committee should submit its report by the 31st December 1973.

2.2 The Committee met Shri T.A. Pai, Minister of Steel and Mines on 7th of December,1973 and discussed the scope of work to be undertaken by the Committee. The Committee is required to give recommendations not only with regard to the consumption of steel but also measures needed to optimise production and to restrict import of steel. The Minister also desired that a review be made of the earlier reports on economy in steel made by different organisations and committees, and such of the recommendations which have not been implemented as yet be pinpointed. Suggestions for the procedure to be followed and organisation to be set up so that such of the recommendations that are acceptable to the Committee are fully implemented, may also be given. The report is to indicate separately the short-term and the long-term measures proposed. The date for submission of the report was changed to 31st January,1974 from 31-12-1973 notified earlier.

2.3 The Committee met in Rail Bhavan, New Delhi thrice on 6-12-1973, 17-12-1973 and 21-1-1974 before finalising this report.

2.4 In the limited time at the disposal of the Committee, it was not practicable to issue a questionnaire to outside bodies and collect information ab initio. Investigations were, therefore, done making use of the information readily available and the recommendations made based thereon.

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2.5 Acknowledgment.

At the request of the Committee, Ministry of Transport and Shipping (Roads Wing), National Buildings Organisation, New Delhi, and Structural Engineering Research Centre, Madras, extended their co-operation by furnishing the information readily available with them and also made valuable contributions. The Army Headquarters Engineer-in-Chief's Branch, New Delhi, Tata Engineering and Locomotive Company, Bombay, Shri B.V.Rao of Ascu Hickson Ltd., Calcutta, Major K.A. Jhangiani, Consulting Engineer, Bombay, and Spiral Tubes, Hyderabad, voluntarily sent very useful suggestions on the subject. The statistical data on iron and steel was obtained from the Iron and Steel Controller, Calcutta. The Committee wish to express their gratitude to these organisations and individuals.

Shri C.Balasubramanian, Dy. Director Standards (Bridge and Structures), R.D.S.O., was associated with the Committee from its very inception and has rendered valuable assistance to the Committee in working out details and in drafting this report. The Committee would like to place on record their appreciation for the assistance rendered by Shri C.Balasubramanian and his staff.

The Committee are thankful to Dr.Krishna Swamy, Joint Director (Timber) and Shri G.H.Jagdale, Dy. Director (Track), Railway Board, for their contributions pertaining to timber and railway track, respectively. The Committee wish to thank Shri N.Gopalan, Dy. Director Civil Engineering (General), Railway Board, for the excellent arrangements made for holding the meetings.

The Committee's gratitude is also due to Shri R.M. Sambamoorthi, Director Standards (Civil), Shri K.Santhanam, Director Standards (Wagon), Shri A.K.Bhattacharyya, Director (M&C), Shri G.V.Himatsinghani, Jt. Director Standards (Carriage), Shri M.N.Prasad, Jt. Director Standards (B&S), and Shri V.K.Raizada, Dy. Director Standards (Track) of R.D.S.O. for the keen interest they have shown in assisting the Committee in bringing out this report.

Shri Ajitha Simha, Director (Civil Engg.), I.S.I., and Shri A.K.Banerjee of Metallurgical and Engineering Consultants (India) Limited made constructive suggestions on the subject. Shri S.M.Chakravarty, Director, Ministry of Heavy Industry and Shri P.Padmanabhan, Executive Engineer, Central Designs Organisation, C.P.W.D. assisted the Committee in its proceedings. The Committee wish to express their sense of gratitude to these officers for their valuable help.

CHAPTER III

STUDIES MADE EARLIER AND THE EXTENT OF IMPLEMENTATION OF RECOMMENDATIONS MADE THEREIN.

3.0 The subject of economy in consumption of steel in the country had been examined from time to time by a number of Committees and organisations. Most of these studies were with regard to the saving of steel in Civil Engineering works only. It is profitable to compile at one place the results and recommendations that emanated from these studies.

3.0.1 Shortly after the attainment of independence, ambitious plans for rapid industrialisation of the country were formulated. Steel being an essential basic raw material for all industries, serious thought was given to increase its production. Simultaneously, the questions of effecting savings in steel consumption assumed urgent importance for a speedy development of national economy. The realisation of this fact led the Director General of Industries & Supplies, Government of India, to request the Institution of Engineers (India) to examine the question of conservation of steel from all aspects. A committee was appointed by the Council of the Institution of Engineers in May 1949 under the Chairmanship of late Dr. A.H.Pandeya. This Committee submitted a report to the Ministry of Commerce and Industry (Development Wing, Co-ordination) in October 1950 and had made certain recommendations regarding the manner in which steel economy could be achieved. Subsequently, on a reference from the Ministry of Commerce and Industry (Engineering Division), the comments of the Steel Saving Committee, on the "Summary of the Fourth Report of the Steel Economy Committee" of U.K. were furnished to the Government of India in March 1952.

3.0.2 In 1950, the Planning Commission recommended to the Government of India that the Indian Standards Institution should undertake a programme for increasing efficiency in the use of structural steel, by the formulation and implementation of standards relating to its production and use. Accepting this recommendation, the Government of India requested the ISI to take up a steel economy programme to include:

(a) Formulation of Standards for hot-rolled sections;

(c) Formulation of Codes of Practice for the use of steel in structures;

(d) Preparation of typical designs and drawings for and other aids to the implementation of the higher efficiency standards;

(e) Preparation of Standard Specifications, Codes of Practice and other publications for popularising welding as a medium of fabrication of steel; and

(f) Sponsoring experimental and other investigations necessary for the formulation and revision of higher efficiency standards, relating to production and use of structural steel.

In the ISI, this work was entrusted to the Structural Steel Sectional Committee SFC:7, which had representatives of the main producers of steel, Ministries of Iron & Steel, Railways and Transport, N.B.O., CPWD, etc. The Steel Economy Section of ISI was manned by an officer on special duty, Shri T.V.Joseph, a senior engineer, whose services were made available by the Ministry of Railways. Under an agreement finalised with the United States Technical Co-operation Mission (India), M/s. Ramseyer and Miller Inc., Iron & Steel Industry Consultants, New York also rendered technical assistance to the ISI in this project. The work was started in February 1954.

3.0.3 Simultaneously, with the progress of work made by the ISI Committee, the Ministry of Works, Housing and Supply instructed the National Buildings Organisation in September, 1956 to constitute a technical committee to explore all possible avenues leading to economy in the use of steel in building construction. The Committee consisted of the Director, N.B.O. as its Chairman with six members drawn from the Ministries of Defence, Railways, Steel, Works Housing and Supply and the ISI. Some more members were co-opted subsequently. The observations and recommendations of the committee are contained in the printed report published by N.B.O. in October 1957.

3.0.4 With the completion of most of the works undertaken by ISI under the steel economy programme, ISI requested the National Council of Applied Economic Research to undertake a detailed and objective assessment of the possible saving in steel through standardisation arising out of the work done till then by ~~ISI~~. The Council was assisted in this study by an Advisory Committee with representatives from ISI, Braithwaite and Company and M.N.Dastur and Company. The Council issued a questionnaire to nearly 150 steel fabricators, consulting engineers, etc., all over the country and based on the information furnished by about 30 of them regarding details of structures fabricated, the savings that would accrue if all the Indian Standards formulated could be fully implemented were worked out. The Council published its printed report "Savings in structural steel through standardisation" in 1965 and this contains a number of useful recommendations.

3.0.5 The Government of India in the Ministry of Steel and Mines took note of the report of NCAER and realized that if the savings mentioned in the study were to be achieved, it would be necessary for co-ordinated action to be taken by the producers of steel, by the designers of steel structures and by the steel fabricating industry. A Committee under the Chairmanship of Shri N.N.Wanchoo, Secretary, Ministry of Steel and Mines was constituted in December 1965 to discuss the entire subject including the concrete steps to be taken. All the Steel Plants, ISI, Ministry of Railways, Ministry of Defence, CPWD, Indian Engineering Association, Dastur and Company, Jessop and Company, and Braithwaite and Company were represented in this Committee. A sub-committee assisted by five working groups went into the details for nearly an year and a half. Based on their report, the Committee formulated a number of recommendations, which are contained in the Minutes of the Committee's meeting held on 26-5-1967.

3.0.6 Subsequently, a committee with the Joint Secretary, Department of Steel as Chairman, the Industrial Adviser, Department of Steel as convener and representatives from the Ministries of Transport and Defence, CPWD, NBO, CBRI and DGTD as members was constituted in June 1971 to consider substitution/reduction in consumption of steel in Civil Construction. This Committee had two meetings and made a number of useful suggestions, as revealed in the record note of discussions of the meeting held on 27-12-1971.

3.0.7 At the Annual Session of the Institution of Engineers at Trivandrum in January 1957 arising out of discussion on a paper "Economy in Steel - a Pressing Problem" by Mr. V.Cadambe, a Committee was constituted under the Chairmanship of Mr. K.[illegible]. Nadirshah to go into the question of steel economy. Final Report of this Committee on steel economy was submitted to the Secretary to the Government of India, Ministry of Steel, Mines and Fuel, New Delhi, in December, 1958.

3.0.8 In the subsequent paragraphs, the aspects of work done by the different committees mentioned above (except 3.0.7) and the recommendations made are summarised.

3.1 Committee of Institution of Engineers (India).

The Committee, appointed in May 1949 by the Institution of Engineers under the chairmanship of the late Dr. A.H. Pandeya, suggested:

(a) the use of alternate materials to the maximum possible extent;

(b) making improvements in design procedures by improving the existing codes;

(c) the increased use of steel of higher performance and rationalisation of steel sections; and

(d) the promotion of welding in place of riveting.

3.2 Steel economy programme of I.S.I.

As a result of the assignment given to the I.S.I under the steel economy programme, after years of continuous study and deliberations by expert panels and study groups, a number of standards of hot rolled sections and cold formed light gauge structurals, codes of practice for use of steel in building construction, specifications for electrodes, wire, flux and their use, standards for welding of structural steel and a few handbooks have been published. The Technical Committee of the I.S.I. entrusted with this work held the view that if all the standards published were fully implemented by the steel producers, designers and fabricators, a saving upto 25 per cent in structural steel could be achieved.

3.2.1 Although, originally the work was entrusted to the Committee BDC-7, subsequently in 1956, the need and the advantage of co-ordinating the production-and-use aspects in the standardisation of metals led to the setting up of a separate Division Council for the work, viz., the Structural and the Metals Division Council, SMDC. This Division Council is constantly reviewing the present standards (codes and specifications) and wherever warranted, arranges for revisions to keep up with the research and developments in the country and abroad to achieve greater efficiency and economy in use of steel.

3.3 Report of National Buildings Organisation.

The Committee set up by the N.B.O. realised that economy in the use of steel in buildings could be effected in several ways and concerted and co-ordinated drive was necessary on all possible fronts to obtain conspicuous results. Thus, the saving may be through rationalisation of bye-laws and codes of practices, rationalisation of design methods, improvement in constructional practices and substitution by other suitable materials. Keeping these aspects in mind, the Committee made a number of recommendations to the Government for their consideration, a summary of which is given below :

3.3.1 The immediate measures needed include adoption of higher stresses, more rational use and design of steel structures and use of substitute materials. The long-term measures include imparting training, encouraging better design practices, use of new techniques and substitution by sophisticated materials.

3.3.2 The use of structural steel in building construction should be reduced to a minimum by substitution by reinforced concrete and prestressed concrete and where possible and economical, by timber and aluminium where such substitute materials are available.

3.3.3 A statement indicating the recommended use in the order of preference of different materials and type of construction for different building components was given.

3.3.4 Since MS bars and rods are the categories to be preferred to structurals, the Ministry of Steel and the Iron and Steel Controller should investigate the possibilities of turning out more MS bars and rods than at present, sacrificing, if necessary, equivalent quantities in the category of structurals.

3.3.5 (a) The need for substituting structural steel and ordinary reinforced concrete by prestressed concrete is vital in the present context of shortages of both cement and steel.

(b) As a positive step towards this end it is necessary to ensure that adequate quantities of prestressing steel should be available in the country from which the intending consumers can draw without going through the time consuming procedure of importing their requirements for each use as is being done at present.

(c) For this purpose it is considered necessary to stock some quantities of this material against anticipated demands. (An outline of organisation necessary for this [illegible] also recommen

3.3.6 Roofs of many buildings can be changed to timber construction. Steps should be taken to make available in the market adequate quantities of treated timber of secondary species for structural use.

3.3.7 To reduce dead weight in structures and consumption of steel, light weight construction is essential for multi-storeyed buildings. Plants should be set up immediately for producing hollow clay tiles and hollow concrete blocks with light weight aggregate in principal areas where multi-storeyed construction is coming into practice.

3.3.8 Use of deformed reinforcing bars in concrete can bring considerable economy in use of mild steel reinforcements. These rods may be made available in the market quickly and these may also be made available in preference to plain bars and rods.

3.3.9 IS:875 in respect of loadings on structures should be followed, as far as possible, by all Government departments.

3.3.10 The Government may make it mandatory for all departments to follow IS:800 for design of steel structures.

3.3.11 Where use of structural steel is unavoidable, welding is to be preferred to riveting. For this purpose, designs on recognised principles of plastic theory should also be adopted.

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3.3.12 It will be advisable for the officer approving the design, to record in each major design, a certificate to the effect (a) that the use of structural steel has been avoided wherever possible and limited to the minimum in other cases; and (b) that the loads, stresses and design practices adopted are in conformity with IS: 800. It is further considered that similar certificate from a Chartered Engineer may be insisted upon in respect of all designs in the private sector in which substantial quantities of structural steel is released either by the Provincial Iron and Steel Controller or by the Ministry of Commerce and Industry.

3.3.13 Permissible stresses in M.S. reinforcements in RC work may be increased and this subject may be referred to ISI for their consideration and decision.

Note: This is being reviewed by ISI from time to time.

3.3.14 About one third of the quantity of M.S. bars and rods are at present marketed as untested. Permissible stress adopted for this category of steel by some departments is only 16,000 lb/sq.in. Most of these bars are rolled from billets falling slightly short of the standard specifications. The Committee feels that the Iron and Steel Controller may arrange to market this steel as 'tested' but certified to a lower class, say Class II, with guaranteed physical properties. The permissible stress for reinforcing bars of this class shall be considered and laid down by the relevant Committee of the Indian Standards Institution.

Note: IS: 1977 for commercial quality steel is published and the relevant IS design codes revised to indicate permissible stresses for this steel.

3.3.15 Considerable economy in cost and in steel will arise out of rationalised design of foundations and structures. Specialists are necessary for this purpose. The National Buildings Organisation will be the appropriate body on whose establishment such specialists required for consultancy could be borne.

3.3.16 Most design authorities could keep target figures for use of steel for various types of buildings from analysis of buildings already designed, and the designers should see that these target figures are bettered every time. Periodical publication of such figures by a body like the National Buildings Organisation will be helpful in the sharing of such knowledge.

3.4 Study by N.C.A.E.R.

3.4.1 This study was based on the data collected regarding indigenous production and import of structural steel and its use in fabricated structures during the Second Five Year Plan period. The savings assessed are based on a very simple, but important assumption that all the Indian Standards formulated till then would be fully implemented. This meant that the country would be able to roll and make available all the rolled sections shown in Indian Standards (including light beams and channels), fusion welding quality steel and steel strip for making tubes and cold formed sections would be available in sufficient quantities and that the fabricating industry would be geared up fully for production of welded structures, including acquiring necessary equipment and trained welders.

3.4.2 As a result of intensive study made, the findings and conclusions were drawn under the following heads:-

(a) Standardisation and rationalisation of steel sections and design practices;

(b) Increased use of welding;

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(c) Adoption of tubular construction; and

(d) Adoption of cold formed light gauge sections.

Under these four categories, the Committee estimated that the total saving in steel would be 23.6 per cent. The aggregate saving in structural steel during the Second Plan period as per this theoretical study, should have been 4,20,000 tons at 23.6 per cent. As against this, the actual estimated saving achieved was only 42,000 tons, i.e., 2.4 per cent. The reason for this shortfall was that the assumptions made in working out the savings were not realistic and most of the measures required were not/could not be adopted.

3.4.3 The possible savings assessed for the Second Five Year Plan period were projected for the Third, Fourth and Fifth Five Year Plan periods and the savings were estimated in the report, as under:

Description.	Third Plan.	Fourth Plan.	Fifth Plan.
(a) Anticipated production of fabricated steel structures ('000 tons).	3,900	7,600	12,600
(b) Saving ('000 tons)	920	1,790	2,970
(c) Saving (Rs. crores)	64.4	125.3	207.9

The above estimates are based on the assumption of 23.6 per cent saving.

3.4.4 Several important aspects of steel economy had been drawn up by this study and the following recommendations were made in this regard, for urgent attention of the Government of India and the producers and users of steel.

3.4.5 Indian Standard steel sections are more efficient than sections hitherto used in the country or overseas thus resulting in substantial saving in steel. It is important that the integrated steel plants in the country should switch over to the production of Indian Standard sections, particularly the light weight beams and channels (ISLB and ISLC) which contribute to the maximum saving of steel.

3.4.6 The rationalised list of steel sections for immediate production in the country was recommended by a committee under the Chairmanship of the Iron and Steel Controller, Government of India. This recommendation was based on the study made by the Committee on Steel Rationalisation of the

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Indian Engineering Association. It is essential that a more comprehensive study should be made in order to consider the possibility of reducing the number of steel sections now included in various Indian Standards.

3.4.7 Although the Indian Standards for beam and channel sections were formulated in 1957 in consultation with the producers, the steel mills have not been able to produce so far the light weight sections. The main reasons advanced by the steel mills have been extensive roll wear and loss in production. It is essential that the technical committee of ISI should review the profile details of the light weight sections in the light of experience gained and modify them so that these could be produced in the country on economical basis.

3.4.8 It is essential that all design offices should use Indian Standard Codes of Practice for design of steel structures.

3.4.9 Preparation of handbooks for Structural Engineers was one of the important items included in the Steel Economy Programme of ISI. So far, only four handbooks have been published. It is important that ISI should expedite preperation of all the handbooks so that the Indian Standards published can be properly applied in actual practice.

Note: The handbooks for structural engineers so far published are as under:

SP:6(1)-1964 - Structural steel sections.
SP:6(2)-1962 - Steel beams and plate girders.
SP:6(3)-1962 - Steel columns and sheets.
SP:6(4)-1969 - Use of high strength friction grip bolts.
SP:6(5)-1970 - Cold formed, light gauge steel structurals.
SP:6(6)-1971 - Application of plastic theory in design of steel structures.
SP:6(7)-1973 - Simple welded girders.

3.4.10 As subtantial saving in steel can be achieved through adoption of welding, use of welded structures should be encouraged. Indian Standards covering all aspects of welding have already been published. The following measures should be adopted to implement these standards:

3.4.10.1 Existing facilities for training and testing of welders should be enlarged so that competent welders are available in large numbers to the fabricating industry;

3.4.10.2 Steels of weldable quality should be made available in sufficient quantities;

3.4.10.3 Arrangements should be made for manufacture of electrode quality steel to avoid import of such steel and/or electrodes; and

3.4.10.4 Capacity for fabrication of welded structures should be increased.

3.4.11 Tubular structures should be used in all locations where heavy loads, such as those due to cranes, are not encountered. In order to encourage the use of tubular structures, tubes conforming to IS: 1161-1963 should be made available to users in sufficient quantities. Tubes of sizes larger than 6 in. dia. are not being manufactured in the country at present. Steps should be taken to produce tubes of larger diameters to enable wider adoption of tubular structures.

3.4.12 Use of cold formed light gauge steel sections contributes to the maximum percentage savings in steel. These sections should be used for purlins in all steel structures. These should also be used for all other components of structures where concentrated loads, such as those due to cranes, are not encountered. Production of cold formed light gauge sections should be stepped up in order to encourage use of these sections in structures. Steel strip conforming to IS: 1079-1963 should be made available in sufficient quantities for cold forming into shapes specified in IS: 811-1961. Although the locations where tubular structures and cold formed light gauge sections could be used are more or less identical, as far as possible, preference should be given to cold formed light gauge sections in structures in the interest of greater economy in steel.

3.4.13 As cold formed light gauge sections are produced from very thin steel strips, it is important that suitable corrosion protective measures are adopted. ISI should expedite formulation of codes of practice for protection of light gauge steel structures.

3.4.14 It is also important that all Indian Standards relating to production and use of steel should form part of the curricula for study in all the engineering colleges and other technical institutions as this would ensure wider implementation of these standards.

3.4.15 Although the resultant savings due to implementation of IS: 1570-1961 have not been taken into account in this study, it is important that the Government should take steps to ensure that only steels conforming to this standard are manufactured and used in the country in order to derive the maximum benefit from standardisation and rationalisation of alloy and special steels. Further, wherever foreign countries collaborate in various industrial undertaking, it should be ensured that steels conforming to IS: 1570-1961 are used.

3.5 Wanchoo Committee Report.

The minutes of the meeting of the Committee on saving in structural steel through standardisation held on 26-5-1967 contain a few recommendations on the report of its sub-committee, the gist of which is given below:

3.5.1 Production of IS Medium beams without relaxation.

The proposal for withdrawing relaxations for beams of depth below 200 mm may be re-examined by ISI keeping in view the difficulties expressed by the producers.

Note: ISMB sections with relaxed dimensions have been accepted in 1972 as standard sections.

3.5.2 Production of light weight sections.

The following light beam and light channel sections should be developed:-

Beams - ISLB 300, 200, 175 and 100.

Channels - ISLC 300, 200, 150 and 125.

It was also decided that TISCO should roll ISLB 100 and ISLC 125, and Bhilai should roll ISLB 300 and ISLC 300. JPC was to allocate the remaining sections to other producers.

Relaxations on the light sections were to be examined by ISI and an amendment issued.

Note: Amendment has been issued by ISI.

3.5.3 Reduction in the list of standardised sections.

The question of reducing the list of standardised sections may be taken up by ISI after the international list of standardised items is completed.

Note: ISO work is still not complete.

3.5.4 Enlarging the list of rationalised sections being rolled by the main producers.

Rationalisation of the following items was approved:

ISLB	300	ISLC	300
"	200	"	200
"	175	"	150
"	100	"	125

3.5.5 Setting up of plant for auto fabrication of structural forms (including beam and column sections).

The Sub-Committee had recommended setting up in a phased manner of six units, each with a minimum capacity of 35000 tonnes per annum, to manufacture continuous welded structures. The committee accepted in principle the recommendations of the Committee. It was also decided that Government should not give any guarantee about supply of plates for the plants, even though all possible help would be extended.

Note: No such plant has been set up.

3.5.6 Enhancing the capacity in the country to produce welded structures and to propagate the use of welding.

Observing that only 60 percent of welding capacity of fabricators was being utilized then, the Committee decided that there was no immediate need to enhance the welding capacity in the country. The Committee noted that Indian Institute of Welding who were conducting a survey on the adequacy of trained welders and available X-ray facilities in the country would submit the report shortly. ISI was requested to consider the possibility of using weldable steel in semi-killed quality instead of killed quality in view of the price differential between the two.

Note: The question was referred by ISI to Indian Institute of Welding but their firm opinion is not yet available.

3.5.7 Reducing the cost of tubular and cold formed structurals.

It would be difficult for the Government to accept the recommendations to bring down the excise duty on skelps and strips which are used in the manufacture of tubes and light gauge structurals. Amendment to loading standards prescribed in IS: 875-1964 would be pursued by ISI.

3.5.8 Other designs likely to save steel and likely saving.

In regard to other designs matters to save steel and the correct figures of anticipated savings as indicated in the recommendations made by working groups IV & V, there was some difference of opinion and the sub-committee was asked to review the matter once more and report to the main committee. The representative of NCAER stated that the savings as originally anticipated in the publication were not likely to materialise.

3.5.9 Use of high strength deformed bars.

The Committee recommended that ISI should formulate the standards and while doing so, keep in mind any possible infringement of patent rights.

Note: The Indian Standards have been prepared keeping this in view.

3.6 Committee under the Chairmanship of Joint Secretary, Department of Steel.

Summary of the discussions of the Committee held on 27-12-1971 is as under.

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3.6.1 Use of high strength deformed bars instead of MS bars (applicable for all RC).

The main bottleneck in the use of deformed bars was its inadequate availability and steps could be taken to increase the production of high strength deformed bars in place of MS bars. In the present context of acute shortage of MS bars for reinforcement, it was felt that if the entire quantity of steel available for civil construction is made in the form of deformed bars, 50 per cent additional civil construction could be carried out with the same quantity of steel. Possibility of using commercial quality billets, if not offgrade billets, for the manufacture of deformed bars may be investigated quickly by the ISI for further increasing the production of deformed bars. Some of the re-rollers are making ordinary round bars out of tested quality billets. The reason for this was that twisting facilities were not available with them. Cold twisting facilities in the country should be augmented. Tested quality billets should be used only for production of deformed bars. In addition to the twisting facilities available with the main steel plants, adequate facilities should also be made available to the re-rollers. (Action was to be taken by the Department of Steel and ISI.)

3.6.2 Construction of load bearing walls upto 4 storeyed construction (applicable for residential buildings).

Only load bearing walls should be used without any RC framed structures. 1½ brick walls instead of 1 brick walls could be constructed in ground and first floors if bricks are not of adequate strength. Brick industry should be developed and encouraged to produce high strength bricks by adopting mechanised production methods and also using new techniques developed by the CBRI. The brick industry should be brought partially under an organised sector for its scientific development. (Action was to be taken by Ministry of Works and Housing and N.B.O.).

3.6.3 Use of AC sheet/asphaltic corruugated sheet instead of CGI sheets for sloping roofs.

Since the asbestos fibre is to be imported, Department of Mines was requested to take action for mining and developing asbestos fibre. N.B.O. should take action regarding development of asphaltic corrugated sheets.

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3.6.4 Use of timber including secondary species in place of steel frames for doors and windows.

Use of steel frames for doors and windows should be avoided and timber should be used instead. Ministry of Food and Agriculture were to take action for making available treated secondary species of timber in market.

3.6.5 Use of brick arches instead of RC lintels for residential buildings.

The scope is limited to low cost houses.

3.6.6 Use of 7.6 cm thick precast lintels with minimum reinforcement upto 1.83 m span (applicable for residential buildings).

This should be popularised for extensive use. Ministry of Works and Housing were to take action.

3.6.7 PVC pipes for cold water supply.

Extensive use of these will largely depend upon the systematic development and introduction of the products within the country. Their use should be popularised.

3.6.8 PVC conduits for electrification.

This is already in practice and has been accepted for civil construction.

3.6.9 RC framed structure with partition walls of light weight blocks or cellular blocks in multi-storeyed buildings.

While it was generally accepted that this could be used extensively the main bottleneck is its inadequate availability. It was mentioned that the factories for manufacture of cellular concrete blocks had been set up at Ennore (Madras) and Poona (Maharashtra) with capacities of 1,38,000 Cu.M. (70 million brick equivalent) and 70,000 Cu.M. per annum respectively and they had gone into trial production. The HHF has been producing small quantities of cellular concrete. As its volume to weight ratio is high, it would not be possible to transport the material in large quantities to longer distances. The units thus set up could serve the requirements of the area within 70 to 80 km radius. It was, therefore, felt that there was scope for setting up more such units adjacent to thermal power plants where fly ash was available as a waste product from thermal power plants. The Ministries of Works & Housing and Irrigation & Power were to take up the establishment of a few more units and take necessary steps with the Ministry of Industrial Development in this direction.

3.6.10 Un-reinforced cellular units resting on joists, doubly curved shell units and channel units for roofs/floors of residential buildings.

There is need to popularise the application of such practice through Government construction agencies and the Association of Architects.

3.6.11 Aluminium fittings for doors and windows in place of steel.

This is already in vogue. At present, availability of aluminium fittings is limited due to short supply of aluminium. The use of aluminium fittings would pick up when these fittings are available at competitive price and availability of aluminium improves.

3.6.12 RC columns and shell roofs like folded plate roof, hyperboloid roof and conoid roof instead of steel structures for industrial buildings.

This practice is already in vogue. The use of RC columns and shell roofs such as folded plate roofs, hyperboloid and conoid roofs instead of steel structures could be popularised and directives given to the Construction Organisations under the Ministry of Works and Housing and also to Associations of Private Architects.

3.6.13 Composite construction with prestressed beam and slab instead of RC slab and beam for highway bridges.

Such practice is in vogue. The main bottleneck in the application of prestressed construction is the inadequate availability of high tensile steel wires required for the fabrication of prestressed concrete structures. The Department of Steel may be requested to take steps for augmenting production of high tensile steel wires. Information may also be passed on to the Government Construction agencies engaged in the construction of bridges to make use of prestressed concrete wherever practicable. The Ministries of Transport, Works & Housing and Defence, Border Roads Organisation, etc., were to take appropriate steps.

3.6.14 Provide plain concrete arch spans with only surface reinforcement for culverts and minor road bridges instead of RC columns and slabs.

It was felt that spun RC pipes could be used for small culverts upto 1.5 metre diameter. The State PWDs may be requested to implement this suggestion.

3.6.15 Use of Neoprene bearings instead of metallic rollers and rockers for highway bridges.

This practice is already in vogue for spans upto 25 metres only. The Ministry of Transport were to keep this in view in their construction programme.

3.6.16 Use of light weight aggregate in multi-storeyed buildings.

This has been technically accepted. The Ministry of Works & Housing and the Ministry of Industrial Development were to take steps to set up plants for production of light weight aggregates, particularly in Metropolitan Cities where multi-storeyed construction is in vogue.

3.6.17 Use of sand-lime bricks/high strength bricks of more than 100 kg/sq.cm. for load bearing walls in multi-storeyed buildings.

The industry for making such bricks should be established in Rajasthan, Madhya Pradesh, Andhra Pradesh, Karnataka, etc. where good quality soils are not available for manufacture of high strength bricks, but lime and sand of the requisite specifications are available for manufacture of sand-lime bricks. The Ministry of Works & Housing and the Ministry of Industrial Development were to take necessary steps to set up this industry in these regions.

3.7 Extent of implementation of recommendations.

In the limited time at the disposal of the Committee, it has not been possible to go in detail the extent of implementation and the difficulties encountered therein with respect to each of the recommendations made in the above reports. Broadly, some of the important recommendations and the progress of their implementation can be summarised under two categories:

(a) The action required to be taken by the producers; and

(b) action required to be taken by the designers and fabricators.

3.7.1 Action to be taken by the producers.

3.7.1.1 High strength deformed bars.

Invariably all the reports had emphasized that considerable economy in steel could be achieved by substituting steel construction with RC using high strength deformed bars. With this in view, even as early as 1957, it was proposed that these bars might be made available in sufficient quantity in the market, that too in preference to plain bars and rods. The Committee is constrained to note that significant progress in this direction has still not been made and this one item, if implemented, would have saved considerable quantity of steel to the country, as substantial quantity of steel produced is used in reinforced concrete work only. ISI published a standard for high strength deformed bars, as early as in 1961.

3.7.1.2 Light beams and channels and increase in number of rationalised sections.

Another aspect that had been stressed by the different Committees was regarding increase in the number of rationalised sections and the need for producing light beams and channels, which are more efficient in the use of steel. The Wanchoo Committee took note of this and approved rationalisation of a few light weight beams and channels and allocated some items to TISCO and HSL/Bhilai, in consultation with them. These light weight sections have not yet been included in the list of rationalised sections by JPC. It is understood that efforts made by Bhilai Steel Plant to get orders for a minimum quantity consistent with economic rolling of ISLB 300 and ISLC 300 sections were not successful.

3.7.1.3 Skelp and strips.

Since use of tubular sections and cold formed light gauge structurals will result in considerable saving of steel, it was suggested by these committees that the skelp and strips required for manufacture of these should be produced in greater quantity and their cost reduced. There has been no appreciable progress in this direction. The Wanchoo Committee had decided that it would not be possible to reduce the cost.

3.7.1.4 Plates and steel to IS: 2062.

Adoption of welding in place of riveting will lead to considerable economy in steel. In welded structures, the components are generally of plates. The main bottleneck in increased use of welding for fabrication of structures, is the non-availability of plates. While semi-killed quality steel to IS: 226 may be sufficient in non-dynamically loaded structures, adoption of welding in bridges and in wagons requires use of killed quality of steel. Although the committees had been recommending increase in production of M.S. plates to IS: 226 and also steel plates and structurals to IS:2062, the production of plates in the country is still inadequate. It is understood that structurals to IS: 2062 are being made by Bhilai Steel Plant (BSP) to the extent orders are received. Bulk of the imports is, however, in the form of plates and sheets. If welding is to be popularised, the need for production of more plates is obvious.

3.7.1.5 H.T.S. wires for prestressing.

Substituting structural steel and ordinary reinforced concrete by prestressed concrete is vital in the present context of shortage of both cement and steel and the various reports had emphasized the need for increased production of prestressing steel. Although, there is some improvement in the availability of HTS wires, there is still much scope for increase in the production of HTS wires.

3.7.1.6 Untested steel.

Way back in 1957, the NBO had recommended that untested materials should not be marketed as use of these is uneconomical and wasteful in steel. In spite of a separate standard for commercial quality of steel (IS: 1977) having been framed at the instance of steel manufacturers to enable the producers to test and certify the steel under this class and structural codes for design were revised prescribing stresses for this material as well, finished steel products which are even below the standards prescribed in IS: 1977 are still being produced. JPC has also recognized this and is publishing prices for this offgrade quality steel structurals and plates. Obviously, the use of this offgrade material in structural work will mean permitting much lower stresses and consequent wasteful usage. There would, however, be no objection to semi-finished goods like billets being priced and sold, as untested.

3.7.1.7 Substitute materials for steel.

While the above items generally concern the Steel Ministry, the production of substitute materials in place of steel was to be undertaken by other Ministries. In these cases also, the progress of implementation has been rather slow:

(a) Timber - Ministry of Food and Agriculture was to take action to make available in the market sufficient quantity of treated secondary species of timber. Although the Committee does not possess the data of production of this material and the difficulties encountered in this connection, the fact remains that these are not available in any sizeable quantity in the market.

(b) Light weight aggregate - Another recommendation made was to set up plants for manufacture of light weight aggregates which could be used for production of light weight structural concrete for use in multi-storeyed constructions. Substantial reduction in the deadload of structure will result which will indirectly reduce the consumption of steel. The Ministries of Industrial Development and Works and Housing were required to take action on this recommendation.

(c) P.V.C. pipes - Making available the PVC pipes for water supply has also been stressed and sufficient work is still to be done in this regard. It is also necessary to develop a satisfactory method of joining the PVC pipes.

(d) High strength bricks - Manufacture of sand-lime bricks and high strength bricks was to be undertaken on a large scale and this is yet another direction where progress is still to be achieved.

3.7.2 Action to be taken by designers and fabricators.

The most important action to be taken by the designers is the avoidance of the use of structural steel, as far as possible, by adopting RC or PC. This is specially so in factory buildings, workshops, storage sheds, etc., which at present consume a substantial quantity of structural steel. Another important recommendation to be implemented is regarding use of deformed bars instead of plain bars in RC. Most of the designers in the country are quite conversant with the designs of structures using deformed bars and prestressing wires. But much headway could not be made because of the non-availability of the materials. In regard to tubular construction and cold formed light gauge sections, although a few codes have been published by ISI, they have not become as popular. Added to this is the difficulty in getting these materials in the required quantity. The committees had recommended increased adoption of welding where use of structural steel cannot be avoided, but the welding fabrication capacity of the country requires to be augmented considerably. Facilities for examination of welds and training of welders are still not adequate.

3.7.3 Main causes of inadequate implementation.

It is felt that one of the main reasons that could be attributed to the non-implementation of even some of the most important recommendations of these committees, has been the absence of a separate organisation or machinery having been set up to co-ordinate with different Ministries and to watch and pursue the progress of their implementation. In regard to production of different steel products, the steel plants may be having their own difficulties, but whatever may be the reason, it cannot be denied that reduction in consumption of steel was greately hampered due to the steel plants having not changed their pattern of production to suit the requirements of the country, with economy in consumption of steel as the objective.

CHAPTER IV

PATTERN OF INDIGENOUS PRODUCTION, IMPORT, EXPORT AND CONSUMPTION OF DIFFERENT CATEGORIES OF STEEL.

4.1 Indigenous production of finished steel.

The total production of finished steel during 1972-73 was approximately 5.27 million tonnes as compared to 4.83 and 4.79 million tonnes respectively during the years 1970-71 and 1971-72. Considerable quantity was manufactured by the secondary producers, billet and scrap re-rollers, etc., besides that by the main producers (HSL, TISCO, IISCO and Mysore Iron & Steel Co.). The break up of the production by the main producers and by others is as under:

Table I. (Figures in thousands of tonnes)

Year	Main producers	Percentage	Secondary producers, re-rollers, etc.	Percentage	Total
1970-71	3615	74.9	1212	25.1	4827
1971-72	3423	71.5	1364	28.5	4787
1972-73	3922	74.4	1347	25.6	5269

The category-wise details of production, during these 3 years are indicated in Annexure I. The information is based on the All-India Iron & Steel Statistical Data furnished by the Iron & Steel Controller, Calcutta. It may be observed that the following 3 major groups constitute nearly 2/3rds of the 5.27 million tonnes of finished steel produced in the country during 1972-73 :

Bars and rods:	2.02 million tonnes	(38.33 per cent)
Structurals:	0.85 million tonnes	(16.19 per cent)
Plates and sheets:	0.64 million tonnes	(12.17 per cent)
Total:	3.51 million tonnes	(66.69 per cent)

The production of bars and rods increased substantially from 1.57 million tonnes in 1970-71 to 2.02 million tonnes in 1972-73. While the production of structurals, rails and galvanised sheets showed a decline in 1972-73 as compared to 1970-71, that of black sheets, hot rolled strips and wires registered a sharp increase. Quantum of manufacture of tool, alloy and special steel has been steadily coming down. In other categories of steel, the level of production, more or less, remained the same.

4.2 Pattern of import.

Since the demand for steel has been increasing and the indigenous production is not sufficient to meet this demand, import of iron and steel materials has been resorted to. The particulars of import of iron and steel materials and ferro alloys during 1970-71, 1971-72 and 1972-73 (upto December 1972) together with their value are shown in Annexure II. 1.35 million tonnes of iron and steel materials of value Rs. 228 crores, were imported during 1971-72, this quantity being almost double that in 1970-71. During 1972-73, even in the 9 months' period for which data became available to the Committee, about 9 lakh tonnes costing Rs. 145 crores were imported. The bulk of imports is in the form of plates and sheets of mild steel and tool alloy and special steel.

In 1971-72, out of 10.54 lakh tonnes of mild steel imported, 7.64 lakhs comprised mild steel plates and sheets. The Railways requirements accounted for only 74,700 tonnes. The Committee could not get the details of other bulk users of the remaining major quantity of plates and sheets imported in the country. It is understood that structural fabricators, electricity boards, public sector undertakings and irrigation projects utilize the imported plates, while sheets imported are used by tube makers, automobile industry, oil refineries, drum and barrel manufacturers, furniture manufacturers and small scale industries. Metal can manufacturers consume imported tinned plates. It would appear necessary to identify the industries using imported steel and decide on suitable measures to be taken to reduce consumption of plates and sheets therein. The Committee recommends investigations to be undertaken immediately.

4.3 Pattern of export.

The export of iron and steel materials has gradually started coming down, as it should be in the context of acute shortage of steel for consumption within the country itself. As against 1.34 million tonnes exported in 1970-71, that in 1971-72 and in the 9 months' period of 1972-73 were only 5.92 and 4.29 lakh tonnes, respectively. The information pertaining to exports category-wise is contained in Annexure III. The major quantity exported during 1972-73 was in the categories of pig iron, sponge iron steel powder and shot ferro alloys, ferro alloys and structurals. The Committee has noted that when the country had to import in the 9 months' period April to December '72, nearly 42,600 tonnes of steel structurals, 44,900 tonnes of steel structurals were exported during the same period.

4.4 Pattern of consumption of finished steel products.

The particulars of despatches of finished steel under broad quota heads of various States made by the main steel plants during 1972-73 are shown in Annexure IV. It may be observed that out of 3.24 million tonnes despatched, the Government consumers including Railways accounted for nearly 1.27 million tonnes, i.e., about 39 per cent. The maximum consumption was in the States of West Bengal and Maharashtra, closely followed by that in Railways and in Bihar State. The details of distribution pattern for finished steel manufactured by 'other than main steel plants' could not be obtained.

The details of sector-wise and category-wise supply structure of iron and steel based on JPC data for 1971-72 are shown in Annexure V. In the short time available at the disposal of the Committee and the limited statistical data that could be collected by the Committee, reconciliation of these figures with the total quantity of steel produced in the country could not be made. These figures presumably pertain to despatches from main producers only. This statement indicates some broad details of the consumption pattern industry-wise. The basic industries, the railways and building construction activities are the items making bulk use of steel, as revealed in this statement. However, it is to be pointed out that this may not reflect correctly the consumption pattern as the quantity accounted for is less than what was totally produced in the country during the same period.

CHAPTER V

OBSERVATIONS AND PROPOSALS FOR IMMEDIATE IMPLEMENTATION.

5.0 General including methodology adopted.

Projection of the demand for steel in Fifth Plan period has been made by the Planning Commission and certain forecasts given by them which indicate that the requirements for steel in that period will be much larger than what can possibly be produced in the Steel Plants indigenously. Even during the Fourth Plan period, the demand has outstripped the production, and import in substantial quantities has had to be resorted to. There is a steep rising trend in the cost of imported steel which, at present, is about Rs.4000 to 5000 per tonne including duties, as compared to only Rs.1,800 per tonne of indigenous steel. Import of steel, therefore, inflates the cost of construction in various projects besides draining our meagre foreign exchange resources. There is delay in completion of the projects as well. Steel is becoming scarce everywhere in the world and only a few countries are willing to export to India. This points to the imperative need for restricting use of steel in the country. Measures necessary for reduction in use of steel require coordinated action by producers of steel, designers and fabricators. To expect that all the economy in consumption may have to be achieved from actions to be taken by the consumers only is a misconception. Present design methods and types of structures used will require to be modified and use of substitute materials resorted to. The pattern of production of finished steel products will also have to undergo a corresponding change to suit those modified designs and structures. If these two processes do not go side by side, any efforts made solely by the users will not produce perceptible results in reduction in consumption of steel. It would appear desirable that rather than importing about a million tonnes of steel every year, the extra expenditure involved could, with advantage, be used for incurring capital investment, for changing the pattern of production of finished steel products in the existing steel plants with minimum modifications required (without increasing their installed capacity) and for setting up additional plants for production of steel products, which otherwise are being imported now. Imports may have to be resorted to only in unavoidable circumstances, where a particular special quality of steel is required and its development in the country is not feasible within a short time. It is not prudent to import semi-killed quality of mild steel in any score. This, in essence, will be the basis on which the short-term proposals have been formulated by the Committee. The methodology adopted by the Committee is described below.

5.0.1 A study of the details of categorywise production in 1972-73 of finished steel products indicates that nearly 2/3rds of the 5.27 million tonnes produced in the country is accounted for by the following three major groups :

(a)	Bars and rods	.. 2.02 million tonnes	(38.33 per cent)
(b)	Structurals	.. 0.85 million tonnes	(16.19 per cent)
(c)	Plates and sheets.	.. 0.64 million tonnes	(12.17 per cent)
	Total:	3.51 million tonnes	(66.69 per cent)

Out of 7.04 lakh tonnes of mild steel - semi-finished and finished products - imported upto December, 1972 in the year 1972-73, 4.93 lakh tonnes were in the shape of plates and sheets. Besides mild steel, the major quantity imported pertained to tool, alloy and special steels, the figure for which stood at 1.84 lakh tonnes for the period April, 1972 to December, 1972. It is, therefore, felt that for achieving the objective of reduction in consumption of steel and for cutting down the import of steel, concentration will have to be on the efficient use of bars, rods, plates, sheets and structurals.

5.0.2 Bars and rods.

Out of about 2 million tonnes of bars and rods produced in the country, about one million tonnes in the form of plain round bars is probably used in reinforced concrete work. Measures to conserve use of steel in reinforced concrete work will, therefore, result in substantial saving of steel. If high strength deformed bars are used instead of plain bars as main reinforcement in RC, a reduction of 35 to 40 per cent in steel can be expected in beams and slabs while in the case of columns, an economy to the extent of about 25 per cent can be obtained. With adoption of ultimate strength method of design in RC, particularly in doubly reinforced sections and in those locations where the ratio of liveload to deadload is less, further economy in consumption of steel can be obtained. In RC slabs, additional saving in steel can be effected by adopting the yield line method of design or Hillerborg's strip method (modified). Even a conservative estimate of an overall saving of the order of 25 per cent may result in reducing the consumption by about 0.25 million tonnes of steel per annum. This large quantity of reinforcement of steel conserved will make it possible to undertake 33.33 per cent extra constructional work in RC (without increasing the total output of bars and rods in the country).

Although, the Indian Standard Specification for cold twisted deformed bars was issued way back in 1961, their production lagged behind in India as compared to foreign countries for a long time. It started in a small way in 1967-68 with a production of 4,300 tonnes during that year and increased in 1972-73 to 2,12,000 tonnes. Despite this increase, the production is far short of the requirement. As the substitution of plain bars by high strength deformed bars depends on easy availability of the deformed bars, stepping up the production of deformed bars would be one of the most important steps in steel saving. The Committee considers that the out-put of high strength deformed bars will have to be raised to atleast one million tonnes within a short period, correspondingly reducing the production of plain round bars. The practical way of ensuring that only deformed bars are used in RC is to manufacture the bulk say 70 per cent of the round bars in the diameter range 8 mm to 40 mm as high strength deformed bars. Production of plain bars may be required for use in structures where there is no economy in the use of deformed bars, in stirrups, as temperature reinforcement, etc..

The high strength in the deformed bars is obtained either by cold twisting of mild steel deformed bars or by hot rolling, using suitable grade steel. To enable the primary producers of plain bars and rods to switch over to manufacture of deformed bars, within a short time, change in the steel making process is to be avoided. If the same billets that are used for the manufacture of plain bars and rods could be utilised for manufacture of deformed bars as well, the modifications necessary in the steel plants will be minimum and the desired change in the pattern of production may be obtained smoothly and quickly. With this aim in view, it may be desirable to encourage production of cold twisted deformed bars in preference to hot rolled deformed bars.

Another method of increasing the production of deformed bars is by re-rolling them from scrap rails. About a lakh tonnes of scrap rails may become available every year. The use of these rails directly in buildings or for any other purpose may be stopped, as this results in wasteful use of steel.

Other directions in which economy in consumption of bars and rods may be obtained are by avoiding RC framed structures where load bearing walls would be sufficient and adoption of precast RC units or jack arch with RC beams in floors and roofs instead of RC slabs in buildings with loading bearing walls.

5.0.3 Plates, sheets and structurals.

The other steel products consumed in large quantities in the country are plates, sheets and structurals, most of which it is understood, are used in steel structures. Reinforced concrete and prestressed concrete structures require much less steel as compared to steel structures. It is, therefore, imperative that the adoption of steel structures be restricted strictly to those cases where RC or PC is not technically feasible. Substitution of steel structures by RC/PC may result in about 50-70 per cent saving of steel. Here again, the main bottleneck will be the availability in sufficient quantity of high strength deformed bars for R.C. and the high tensile steel wires for prestressing. The out-put of H.T.S. wires will, therefore, have to be increased in addition to that of the deformed bars. In those structures where use of RC/PC cannot be made and the use of steel is unavoidable, the design methods and the type of structures to be adopted require to be changed to make more efficient use of steel. Use of rigid frames designed on plastic theory, welding in place of riveting and utilisation of tubes, hollow sections and cold formed light gauge structurals instead of hot rolled structurals and plates are a few such proposals. Tubes and cold formed structurals require skelp and strip for their manufacture, production of which, therefore, needs to be stepped up. In welded structures use is made of more plates than structurals and this points to the necessity of increasing the production of plates in the country, to derive the benefits that are possible with adoption of welded structures. For the immediate requirements, the proposals envisage that semi-killed quality MS plates to IS:226 only need to be manufactured in sufficient quantity and these are suitable for welding of non-dynamically loaded structures. Use of welded construction in dynamically loaded structures like bridges, wagons, etc., cannot be achieved quickly as they require killed quality steel to IS:2062 which may have to be imported.

5.0.4 Keeping the above broad outlines in view, the details of action required to be taken by the designers, fabricators, the authorities responsible for preparation of codes of practices and the producers are discussed in subsequent paragraphs.

5.1 Residential and office buildings.

As mentioned earlier, about a million tonnes of steel is used as reinforcement bars in RC work. A substantial portion of this goes into the construction of residential and office buildings. The measures that can be taken immediately for reducing the consumption of steel in such buildings are discussed below. These recommendations are required to be implemented by instructions to be issued by all government agencies and housing boards in the country responsible for construction activities and also by making the necessary changes in the building bye-laws of various local bodies.

5.1.1 Adoption of load bearing masonry structures without RC columns and beams.

Where good bricks are available, load bearing masonry structures without RC columns and beams may be provided in low rise buildings, say upto 4 storeys, depending upon the strength of the bricks. By the use of good quality bricks, having crushing strength of 70 kg/sq.cm. for the upper three floors and 105 kg/sq.cm. for the ground floor and the method of design based on IS:1905-1969, one brick thick walls can be adopted for four storeyed residential buildings instead of RC framed structures. Where the bricks do not have adequate strength to take the load in 4 storeyed construction, 1½ brick walls instead of single brick walls could be constructed for first and ground floors.. Some organisations like C.P.W.D. have successfully adopted this procedure for residential buildings. Use of RC frames cannot, perhaps, be avoided in areas subject to severe earthquake. High strength bricks manufactured by mechanised brick plants, laid in cement-lime-sand mortar resist rain penetration and obviate the necessity for external plastering. Use of high strength bricks in construction of four storeyed buildings is claimed to have the advantages of reducing the use of cement by about 20 per cent, saving in the consumption of steel to the extent of 40 per cent and reduction in the total cost of construction by 10 per cent. C.P.W.D. has already constructed over a 1000 quarters by this method in Delhi. About 60 quarters in 4-storeyed/5-storeyed blocks have also been constructed at Calcutta.

In the case of office buildings where larger rooms are required, this type of construction can be extended by providing a few columns and beams resulting in a partly framed and partly load bearing structure. This type of construction has also been adopted by the C.P.W.D. at Delhi.

5.1.2 Multi-storeyed buildings.

There is no doubt that use of RC instead of steel frames in multi-storeyed buildings say upto 20 storeys will lead to economy in consumption of steel. The quantity of steel required for an RC framed structure is only about half that required for a steel framed structure. Use of composite construction instead of steel beams may also lead to some economy. In U.S.A., RC has been claimed to be economical in overall cost even upto 75 storeys. It is, therefore, recommended that in all cases where adoption of a framed structure for a multistoreyed building is unavoidable, this may be of reinforced concrete construction generally. Where buildings have a large service core to serve as stiff shear walls, combination of RC frames and shear walls may be used. In other cases "framed tube", "tube-in-tube" and "bundled-tube" systems may be suitable, depending upon the height of the building.

5.1.3 Adoption of RC walled structures for tall residential buildings.

In tall buildings, (say about 12 storeys and above) in view of the high lateral forces, the frame members become very heavy and they require a large quantity of steel reinforcement. In residential buildings, such as apartments, hostels, etc., where the walls are located directly one above the other, considerable economy can be effected by providing nominally reinforced concrete load bearing walls instead of a framed structure. The stresses in the walls will usually be within the permissible limits of plain concrete. The walls will, therefore, require only a nominal reinforcement for preventing temperature and shrinkage cracks. The extent of saving in steel depends upon the plan and the number of storeys. For a 16 storeyed hostel building in which the walls could be provided in every bay, it was found by C.P.W.D. that the saving in steel was about 35 per cent. Plain mild steel bars can be used as there is no advantage in providing high strength deformed bars. This type of construction has been adopted widely in many foreign countries. So far this has been adopted only in a few buildings in India. It may be necessary for C.P.W.D. to examine the thermal insulation of the walls in Indian conditions based on a study of the buildings already constructed in the country. If this examination proves their suitability for local conditions, there will be need to popularise this technique in view of the large saving in steel.

5.1.4 Use of light weight partition walls in multistoreyed buildings.

Cellular concrete blocks are manufactured from lime/cement and fly ash/sand. At present, plants set up at Delhi, Madras and Poona, are manufacturing these blocks. The weight of cellular concrete is about 1/3rd the weight of brickwork. Hence if it is used for non-structural partitions in multistoreyed buildings, the deadload on beams, columns and foundation is considerably reduced, resulting in a corresponding saving in the amount of steel used in these structures. The average saving in steel due to the reduction in the deadload is estimated to be in the range of 5 to 10 per cent depending upon the number of partition walls in which the cellular concrete is used. Use of brick partition walls in multi-storeyed buildings may be avoided as far as possible in cities where light weight cellular concrete blocks are being manufactured. In other places also, the use of brick filler walls should be minimised and other types of light weight partitions such as particle boards should be used, wherever possible. Cellular concrete blocks have been used extensively by Tamil Nadu Housing Board at Madras and M.E.S. at Poona.

5.1.5 Use of yield line theory/Hillerborg's strip method (modified) for design of RC slabs.

RC slabs are used as floors and roofs in framed structures as well as in buildings with load bearing walls and they account for a substantial part of the steel reinforcing bars used in buildings. Therefore, any economy in the slab design can lead to appreciable reduction in consumption of steel in buildings.

The design of two way slabs by moment coefficients prescribed in IS:456-1964 has a very high factor of safety against collapse, as proved by extensive studies made all over the world. The yield line theory takes into account the beneficial effects of re-distribution of moments and the design moments are 10 to 35 per cent lower than those given in IS:456 depending upon the span ratio and boundary conditions. Though the design of slabs by yield line theory is permitted by the IS Code, it has not been widely used by engineers perhaps due to lack of design aids and literature for their guidance.

Another equally efficient method of design of two-way slabs is the Hillerborg's strip method (modified). In this method, provision of torsion reinforcements is avoided. Charts and design aids for easy applicability of this method are available and this method could also be incorporated in IS:456 as an alternative method of design of RC slabs.

Wherever RC slabs are provided, the design may be based on either of these two methods to derive the benefits of economy in consumption of steel.

5.1.6 Use of precast flooring/roofing units instead of cast-in-situ R.C. slabs.

Various types of precast floor/roofing units have been developed by C.B.R.I. and S.E.R.C. such as precast trough units, precast cellular units, precast doubly curved shell units, precast cored units, and precast battens and hollow block construction, the use of which results in appreciable saving in consumption of steel and cement compared to the conventional design of RC slabs. Burnt hollow clay blocks of structural quality in conjunction with concrete in RC/PC slabs is also a product developed by S.E.R.C. and claimed to result in saving of steel. The main advantage of precast units is that the speed of construction is increased compared to conventional RC slab roofing and there may be a reduction in the overall cost as well. The overall depth of the floor is higher in the case of precast units. When compared to the design of slabs by the yield line theory, cored units and precast battens with hollow block construction may require more steel than the RC slabs. These types of constructions have, therefore, no advantage from the point of view of economy in steel. Precast trough units, precast cellular units, precast doubly curved shell units and hollow clay blocks, however, result in economy in steel and their use is recommended in preference to other types which require more steel. In this case also significant savings are achieved only when the shorter side of the room to be covered is more than about 3.5m. Their use will perhaps have to be limited initially to mass housing schemes undertaken by different State Housing Boards and government organisations. The public may not be willing to adopt them for building their own private houses for obvious reasons. The types of precast constructions recommended are described in paras 5.1.6.1 to 5.1.6.3.

5.1.6.1 Precast trough units.

It is a precast RC/PC element, trough shaped in section. The units are normally 30 to 80 cm wide. These units have been used experimentally in the College of Military Engineering, in Poona, 16 Type-III quarters at Delhi by M.E.S. and a 2-storeyed building at Madras for Structural Engineering Research Centre (SERC). The clear headroom available is reduced by 3 cm, with their use. They are suitable in span range of 6 to 8 metres. The use of trough units in place of RC slabs is expected to result in a saving of about 10 to 20 per cent in steel and 20 to 25 per cent in cement. It is reported that in the S.E.R.C. building where prestressed concrete units were made use of, saving upto 50 per cent of steel compared to conventional RC beam and slab construction was achieved.

5.1.6.2 Precast cellular units.

This system of roofing consists of hollow concrete units placed on fully or partially precast beams and covered with deck concrete when the supporting beams are partially precast. Adoption of this system of roof is expected to result in a saving of 15 to 30 per cent in consumption of steel compared to conventional design of RC slab and 20 per cent saving in consumption of cement besides reduction of total cost of roofing compared to the design of slab of yield line theory, the saving in steel is only about 15 per cent. The clear headroom available is about 10 to 15 cm less than that with RC slabs. These units have been used successfully in the following projects :

(a) 16-bed hostel for C.B.R.I./Roorkee.
(b) 16 Type-III quarters at Delhi for M.E.S.
(c) 16 Type-III quarters at Simla for Himachal Pradesh, Public Works Department.

5.1.6.3 Precast doubly curved shell units.

The precast units in this system are doubly curved shells of plain concrete. This system is a very economical alternative to the conventional beam and slab construction. The units may be used in conjunction with pre-fabricated beams or battens or planks made of reinforced concrete, prestressed concrete, steel or timber. They may also be used as waffle shells by providing in-situ ribs in two directions. The top is finished flat with in-situ concrete. A saving in steel to the extent of 15 to 30 per cent can be achieved in comparison with conventional RC slab. The construction is also lighter in weight. This is also suited for use as workshop floors and loading platforms carrying heavy loads and eliminates the use of shuttering fully and scaffolding partially. The size of the shell may be chosen depending upon the handling facilities available. The clear head room available will, of course, be reduced to some extent with the use of these precast units. The methods of design and manufacture of precast units and the construction techniques have been codified by the Indian Standards Institution (IS:6332-1971). Waffle shell system has been employed in many large housing schemes and in the construction of many individual buildings. Some of the large schemes in which this system has been successfully employed are the residential colony for the Bharat Heavy Electricals Ltd., Tiruchirapally (over 600 tenements), housing schemes for the Tamil Nadu Slum Clearance Board, Madras (over 250 residential units), and the Andhra Pradesh State Police Housing Corporation, Hyderabad (about 100 units).

Funicular shells were also employed in the construction of a Transit Shed for the Madras Port Trust to carry a heavy design load of 2200 kg/sq.m. The precast shells were supported on main and secondary beams of prestressed concrete.

5.1.6.4 Burnt hollow clay blocks in conjunction with concrete in floors and roofs.

Burnt hollow clay blocks of structural quality can be used in conjunction with concrete in reinforced and prestressed slabs. Precast prestressed slab strips incorporating these hollow clay blocks have been successfully used in the roof of a school building near S.E.R.C., Madras. About 16 per cent saving in steel is claimed. N.B.O. in consultation with S.E.R.C. may arrange for its wide publicity along with details of construction.

5.1.7 Roof and floor with jack arches.

In the traditional form of jack arch roofing, rolled steel joists are used for supporting the brick arches. To avoid the use of new steel, the Railways have been using released rails in place of RSJs. However, this system consumes a large quantity of steel. Now that re-rolling of bars from released rails has been accepted, this system results in avoidable wastage. Instead, jack arches with RC supporting beams are recommended for adoption in floors and roofs of buildings with load bearing walls, in lieu of RC beam and slab construction, as far as possible.

5.2 Industrial structures, storage sheds and other similar structures.

In the study conducted by N.C.A.E.R. it had been brought out that the bulk of steel fabricated for civil constructions pertains to factory buildings. Large quantity of corrugated steel sheets are also used in these buildings. Hence considerable emphasis is to be given in the designs of the structures and roofing for such buildings to obtain economy in consumption of steel plates, sheets and structurals. At present, a majority of factory buildings are of conventional designs with steel columns treated as propped or free vertical cantilevers and simply supported roof trusses. This type of construction may be avoided. Instead, factory buildings and similar structures can be planned either as completely RC structures or partly of RC and partly of steel constructions. Even in industrial structures with cranes of upto medium capacity, RC columns may be used, instead of steel leading to economy in consumption of steel, as revealed in the studies made by Metallurgical and Engineering

Consultants (India) Ltd., Ranchi. Various ways of achieving these objectives are indicated in subsequent paragraphs.

5.2.1 RC rigid frames with deformed bars as main reinforcement.

Considerable economy in steel can be achieved if factory buildings, storage sheds, etc., are designed as rigid frames with RC using deformed bars as main reinforcement. A saving in the range of 40 to 60 per cent over a similar rigid frame of steel designed on plastic analysis can be obtained while the saving over a steel frame designed by elastic method can be of the order of 55 to 80 per cent The Committee, therefore, recommends that all structures for industrial buildings and storage sheds may be constructed, as far as possible, only as RC rigid frames with deformed bars as main reinforcement. The difficulty, however, will be non-availability of deformed bars in the requisite quantity. Therefore, these structures could be of RC with mild steel plain bars as reinforcement, till deformed bars become available. In course of time, with the increase in production of deformed bars, the RC structures will automatically make use of deformed bars only.

5.2.2 Shell and folded plate structures.

Shell and folded plate structures have the advantage that in addition to eliminating structural steel from the supporting framework, the roofing sheets are also avoided. These structures consume minimum amount of cement and steel compared to any form of RC construction. If economy in consumption of steel is to be achieved and at the same time the consumption of cement should not unduly increase, this type of construction should be preferred. The cost of the form work required for shell roofs, however, tends to be expensive, in spite of the low consumption of cement and steel. Hence, these will be suitable only if a large number of identical units are to be constructed. It is suggested that extensive use may be made of doubly curved shells, which are more efficient than singly curved shells. The hyperbolic paraboloid, conoid and the hyperboloid shapes, though doubly curved, have the advantage from the constructional angle that they can be cast on forms composed of straight planks, as they are "ruled surfaces". Conoids are, in addition, suitable for casting with mobile form work. Large workshop structures are eminently suitable for adoption of shell structures in lieu of the steel framed ones now in vogue. Standardisation of these structures may lead to appreciable saving in the total cost, as the form work can be re-used number of times.

5.2.3 Use of precast and prestressed concrete elements:

Another direction in which steel structures in industrial buildings can be replaced is by making use of precast prestressed elements for these buildings. Corrugated shells and funicular shells lend themselves to adoption for precast work and could be easily used for storage sheds and other structures where no crane working is involved. The precast units may also be prestressed in the longitudinal direction for connecting them. Use of prestressed concrete trusses and precast prestressed hyperboloid shells is claimed to save upto 50 per cent of steel when compared to conventional steel trusses. They will also be cheaper in overall cost. These precast units may be standardised by ISI in consultation with S.E.R.C. and suitable design aids furnished to the users for their easy adoption. Standardisation of various components of the structures will help the industry to manufacture these precast products and make available as readymade units in the country.

5.2.4 Funicular brick shells.

Funicular shells with bricks have been built in S.E.R.C. campus at Madras and at the national Institute of Design, Ahmedabad upto a size of 12.5m x 12.5m. Compared to a RC shell, this method resulted in a steel saving of about 35 per cent. N.B.O. may, in consultation with S.E.R.C., publish literature on the subject for its large scale adoption in industrial and storage buildings.

5.2.5 Structures with partly RC and partly steel construction.

If complete RC/PC construction is not feasible in any particular case, part construction of RC may be resorted to. In this type of construction, the supporting structure may be of RC and the roof may be of tubular trusses or structural steel. This is suitable and economical in steel as well for industrial structures with cranes of medium capacity.

5.2.6 Substitute materials for C.G.I. roofing sheets.

At present about 1 lakh tonnes of C.G.I. sheets are used per annum. In addition to the use of steel, this also involves the use of imported zinc for galvanising. It is, therefore, necessary to restrict its use and adopt substitute materials, such as AC sheets and asphaltic corrugated sheets.

AC sheets are a good substitute for C.G.I. sheets and have been in use for a long time. Its major drawback is that the asbestos fibre used in its manufacture is imported. But this has to be weighed against the import of zinc required for C.G.I. sheets. In manufacture of AC sheets use is made chiefly of chrysotile variety of asbestos fibre. Commercially viable deposits of chrysotile grades of asbestos fibre have not so far been discovered in the country which leaves the industry entirely dependent upon imports. Taking into consideration that nearly 50,000 tonnes of asbestos fibre is to be imported each year at the current level of production, the urgency of discovering deposits of asbestos fibre in the country needs no stressing. Amphibole varieties of asbestos have been found in Tamil Nadu, Mysore, Madhya Pradesh, Gujarat, Rajasthan, Uttar Pradesh, Bihar and Orissa. Some work has been done in C.B.R.I. for manufacturing AC sheets using indigenous asbestos fibre. This has to be pursued and follow up action taken for its further development. As a more realistic measure, however, for achieving early results, it might be desirable to aim at development of a partial or full substitute for the asbestos fibre.

Asphaltic corrugated sheets have been introduced recently. It is claimed that they have better thermal insulation than AC sheets. The cost is only about 50 per cent of AC sheets. They have been used in various parts of the country, such as Andhra Pradesh, Tamil Nadu, Uttar Pradesh and Maharashtra. Their life and long-term performance have not yet been established. Moreover, their use will have to be restricted to places where the temperature does not go beyond 42°C (108°F). In view of these factors, their universal use for industrial buildings may not be immediately possible. But they can be used for temporary and semi-permanent buildings. They are also suitable for sloping roofs in coastal areas and hill stations and as roof for rural housing. Use of AC and asphaltic corrugated roofing sheets in substitution of C.G.I. sheets will release the capacity in steel plants for making plates or strips which are in short supply in the country.

5.2.7. Welded construction/plastic design.

Only in those cases where the methods mentioned in paras 5.2.1 to 5.2.6 are not possible to be adopted, use of steel structures may be resorted to. In all such cases, welded construction instead of riveting should be the normal practice and the structures designed as rigid frames, by plastic theory where possible. A saving of about 20 per cent in steel is likely to result if rigid frame for a shed is designed on plastic theory as compared to a design based on elastic analysis. Welding of structures itself is likely to result in a saving of 10 to 15 per cent in steel. Use of plastic designs has not progressed in India to any great extent so far, although the design code for buildings (IS:800-1962) does permit such a design. Recently, I.S.I. has brought out a handbook on the plastic design of steel structures and it is hoped this will aid the designers to go in for this type of design. Its use, however, has to be confined for the present to single storey framed structures subject to static loads only. In industrial buildings with overhead cranes, where designs cannot be based on plastic theory, it is recommended that welded structures based on elastic analysis but designed as rigid frames may be adopted.

5.2.8 Adoption of tubular/hollow sections.

Where structures cannot be designed as rigid frames on plastic theory and use of steel is unavoidable, use of tubular/hollow sections instead of plates and angles is to be preferred. Use of steel tubes in general building construction is allowed in terms of IS:806-1968. Out of 3 grades of tubes, standardised as per IS:1161-63, in tubes to grade YST-25, permissible stresses allowed are more or less similar to the ones in mild steel to IS:226, while in tubes to grade YST-32, still higher stresses can be allowed (although less than those for HTS). The tubular sections are particularly suitable for compression members due to their higher value of radius of gyration for the same area of cross section. Hence in those places where the members are subjected to axial compression, use of tubes in preference to other structurals such as angles will result in considerable saving. For instance in trusses, the consumption of steel can be brought down by 20 to 50 per cent depending on span and the profile adopted. By using tubular sections in light and medium industrial buildings and storage sheds, economy of steel to the extent of 20 to 22 per cent can be achieved even if grade YST-25 to IS:1161 is made use of. If tubes to grade YST-32 are made available in sufficient quantities, the saving will be much more. The field connections of such structures may be either welded or with friction grip fasteners instead of black bolts if they are to be used for heavy constructions. Although there is considerable saving in the quantity of steel used, the cost of skelp used for the tubes is much higher than that of bars, rods and structurals and hence there may not be an overall saving in the total cost of the structure. I.S.I. has prepared a draft handbook on this subject and this may be published early, to aid designers.

5.2.9 Use of cold formed light gauge structurals.

Designs utilising cold formed light gauge steel structural members in general building construction is to follow the practice prescribed in IS:801-1958. A handbook on the design of cold formed light gauge steel structurals has been published by the I.S.I. in 1970. It is claimed that use of these will also lead to appreciable economy in the consumption of steel. The dimensions of cold formed light gauge sections of a few efficient shapes have also been standardised in IS:811. In the N.C.A.E.R. report, it was estimated that a saving of about 40 per cent by weight of steel in structural main members and a saving upto 50 per cent by weight of steel in purlins would be achieved by using cold formed light gauge sections instead of hot rolled sections adopted in conventional sections. Their use is, however, limited to purlins and for all other components for structures where concentrated loads such as those due to cranes are not encountered. The light gauge structurals being very thin require greater care for surface protection like galvanising. This protection is likely to add to the cost of structure over and above that contributed by the high cost of the strips used for manufacture of light gauge sections. Wide use of light gauge structurals is, therefore, not recommended. They may, however, be used in preference to rolled structurals, wherever the use of tubular sections is not feasible.

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5.2.10 Open web structures.

Open web structures consisting of angles in the flanges and rods in the webs are very economical as beam members. These can be used as long span purlins and roof trusses in medium span storage buildings. Such open web frames are used in Railways since long, as for instance purlins for platform shelters. Compared to a solid web beam for the same design load, a reduction of about 70 per cent in steel had been achieved in the present standard space purlins adopted by the Railways. Further economy can be achieved if tubes are used instead of angles and rods. Castellated beams made out of standard RSJs or other rolled shapes with increased depth obtained by forming castellation in the web by cutting and welding are also economical in steel where shear considerations are favourable. I.S. Handbook No.2 on beams covers some typical designs of castellated beam. A saving of about 15 to 35 per cent in steel compared to the designs of conventional beams can be obtained. Their use is to be restricted to lightly loaded locations and not in gantry girders. While the open web beams with angles and rods/tubes can easily be fabricated in any workshop, the castellated beams require automatic cutting and welding equipment and it may not be possible for individual consumers to have the fabrication done by themselves. It is suggested that standardisation of open web structures of either tubes or angles and bar and castellated beams may be undertaken by I.S.I. in consultation with S.E.R.C. S.E.R.C. has also developed open web joists with concrete flange, which is expected to result in a saving of about 30 to 35 per cent of steel. These could also be considered for standardisation. This will enable these items being manufactured by fabricating shops in different regions and made available in the market as readymade ones for use by consumers.

5.3 Platform shelters and foot-over bridges in railways.

These structures, are at present fabricated out of steel. Use of prestressed concrete/RC precast elements for platform shelters, foot-over bridges, etc., instead of steel structures will result in considerable saving of steel used therein. In the case of platform shelters, their adoption can result in conservation of about 40 to 50 per cent of steel and Railways are taking action to standardise them. It is essential that use of structural steel in these types of structures in Railways should be avoided, as far as possible, and resorted to only in exceptional cases. Use of shell roofs for platform shelters will result in further saving in steel but they may, perhaps, be suitable only if a large number of identical units are constructed. Where use of structural steel is unavoidable, tubular sections may be utilised in lieu of rods and structurals, where possible. This may bring about a saving of 15 to 20 per cent in steel used in platform shelters.

5.4 Bridges.

The present practice for design of highway and railway bridges is as follows :

(a) Highway bridges - RC slab for spans upto 8m, RC 'T' beam and slab for spans 8m to 25m and RC balanced cantilever or box girders or prestressed girders for longer spans are generally in use.

(b) Railway bridges - For small spans upto 6m, RC slabs with or without 'T' beams, RC box culverts and RC pipes are generally adopted. Bridges of spans above 6m and upto 25m consist of steel plate girders while longer span bridges are of open web through or underslung type girders. Composite construction of steel and concrete and prestressed concrete girders is also used for spans upto 25m.

Though there is scope for effecting substantial economy in the consumption of steel in bridge girders, most of the measures required are such that they cannot be implemented within a short time. The pace of introducing new types of constructions in bridges has necessarily to be slow and with caution after conducting trials over a reasonable period. Some possible items where immediate economy is possible are, however, outlined in the sequel.

5.4.1 Highway bridges.

Plain concrete arch spans with only surface reinforcement can be used in culverts and minor bridges, instead of RC columns and slabs. The Ministry of Transport have already issued standard designs for segmental arch bridges in plain concrete for spans upto 12m. These may be adopted to the maximum extent possible in all road bridges to be constructed by the State Governments and local bodies. Where use of such arches is not possible, RC slabs can be used with high strength deformed bars as main reinforcement to achieve maximum conservation of steel. The Ministry of Transport, it is understood, are already taking action to revise their standard designs to provide for this. For culverts of 1.5m span and below, RC pipes could be adopted instead of abutments and slabs. In longer span bridges, the girders shall, as far as possible, be of prestressed concrete, with a view to achieving maximum economy in steel. This could be either with prestressed beams and RC slabs or box girders prestressed. Ministry of Transport might consider standardisation of prestressed concrete girders for adoption by all State Governments. As most of the proposals for bridge works in national highways prepared by the State Governments are submitted to and approved by the Ministry of Transport, it should not be difficult for Ministry of Transport to get these recommendations implemented. IRC Code of practice already permits use of deformed bars in road bridges and use of plain MS bars for the main reinforcement in road bridges can be totally stopped, once deformed bars become available in adequate quantity.

5.4.2 Railway bridges.

Short span bridges upto 6m can be precast prestressed concrete slabs instead of RC slabs or 'T' beams at present in use which will result in conserving steel to the extent of 50 per cent. For spans upto 25m prestressed concrete girders may substitute steel girders, in new constructions and in doubling. Calculations indicate that the requirement of steel can be brought down by 60 to 90 per cent if prestressed concrete girders/slabs are adopted in lieu of steel girders of standard riveted design. The Railways have already used a large number of prestressed concrete girders and slabs and their standardisation is being taken up.

In the Fifth Five Year Plan and subsequent periods, a number of projects for converting from MG to BG are likely to be sanctioned. Consumption of new steel can be reduced if released MG steel girders are strengthened and reused for BG loading in these conversion projects, wherever this does not present problems and the existing material is of a quality suitable for strengthening and retention. The Ministry of Railways have already standardised and issued detailed drawings for the strengthening of standard MG ML girders of spans from 6m to 46m. The additional new steel required for strengthening compared to the steel required for a new span shows that a saving of 50 to 85 per cent can be achieved, the larger percentage being in long span bridges. To the extent the existing girders are reused, the demand for new steel will decrease.

5.5 Water-supply installations.

5.5.1 Use of plastic materials.

Pipes and conduits made of plastics offer major substitutes to steel products in building industry. The annual production of GI pipes in the diameter range of 15mm to 100mm alone is as much as 3 lakh tonnes. Zinc, which is used for galvanising these pipes is imported. If PVC pipes are used, there would be considerable saving of steel besides conservation of the foreign exchange used for import of zinc. The use of PVC pipes has the following advantages :

(a) Saving in steel: One tonne of PVC can replace 7 to 8 tonnes of steel pipes.
(b) Economy in cost by 30 per cent.
(c) Lightness and consequent ease of installation.
(d) Corrosion resistance and consequent reduction in maintenance cost.

These pipes can be put in building industry to several uses, viz., internal and external water supply, rain water disposal, drainage, sewerage, etc. Though these pipes have been used widely in Uttar Pradesh, Rajasthan, Delhi, Andhra Pradesh, Tamil Nadu, etc., for potable water supply, their use for sewerage and drainage is still limited primarily on account of non-availability of fittings.

At present, three categories of pipes for potable water supply are being manufactured in the country as under :

Table II.

S.No.	Description	Range of dia.	Range of pressure rating	Reference to IS Code.
1.	Low density poly thylene pipes	8mm to 135mm	4 to 10 kg/sq.cm.	IS:3076-1968
2.	High density polyethylene pipes.	10mm to 50 7mm	2.5 to 10 kg/sq.cm.	IS:4984-1972
3.	Unplasticised (rigid) PVC pipes.	15mm to 315mm	2.5 to 10 kg/sq.cm.	IS:4985-1968

IS:2065-1962 - Code of Practice for water supply in buildings allows the use of polyethylene and UPVC pipes. The IS Codes for pipe fittings and laying and joining of these pipes are in the formulation stage and Indian Standards Institution may take urgent action to have these finalised. One of the main difficulties in using PVC pipes has been the weakness of their joints. It is necessary to develop an efficient and effective method of joining these pipes. Rate contracts may be concluded by the DG S&D for the different and commonly used plastic pipe products so as to increase their popularity with the government organisations and to enable the plastic industry to expand their production. Suitable instructions are to be issued by the government organisations for their adoption in water supply wherever possible.

5.5.2 PC, RC and AC pipes.

While PVC pipes and AC pressure pipes are suitable as substitute for small diameter pipes, prestressed concrete and RC pipes can be used for large diameter pipes in water supply installations. Though use of prestressed concrete and RC pipes does not completely eliminate the use of steel, substantial saving in steel will result. These products could also be standardised to enable producers to manufacture them and make them available in the market. I.S.I. may undertake this work in consultation with Ministry of Works and Housing and the C.P.H.E.R.I./Nagpur.

5.5.3 Water tanks and stagings

Considerable quantity of steel is used in steel water tanks and stagings. If RC water tanks and towers are used instead, it will lead to a saving of about 15 to 35 per cent in steel consumption depending upon the size of the overhead tank and the height of tower. Substitution of plain MS bars by high strength deformed bars will lead to a further economy. It is considered that water tanks and towers should, as far as possible, be constructed of RC. Use of RC tanks may not, however, be practicable in railway yards where these tanks might have to be dismantled and shifted to provide for any future yard remodelling required.

5.6 Steel production.

5.6.1 High strength deformed bars.

As already indicated elsewhere, stepping up the production of high strength deformed bars from the present level of 2.12 lakh tonnes to at least 1 million tonnes, as early as possible, is one of the most important steps in the steel saving. Steps required to achieve this objective are :

(a) Bulk, say 70 per cent, of the production of MS round bars in the range 8 mm to 40 mm may be as cold twisted deformed bars to IS:1786.

(b) Recently, I.S.I. has finalised an amendment to IS:1786 modifying the chemical composition of the semi-finished steel to be used in the manufacture of these bars. The blooms and billets which are at present treated as untested and hence, not efficiently used can be diverted for production of deformed bars without any disadvantage. It is necessary that I.S.I. circulates immediately to all producers and re-rollers the chemical composition of the offgrade quality billets which can be considered suitable for production of deformed bars.

(c) In order to avoid unscrupulous and unauthorised production of sub-standard material, the best way would be to insist on I.S.I.'s Certification Mark for the deformed bars produced. Use of such I.S.I.'s Certification Mark would automatically authorise I.S.I. on the one hand to technically guide the re-rollers and on the other hand to carry out the necessary inspection.

(d) The Government should, however, be more liberal in allowing collaboration for the manufacture of deformed bars or pursuade TISCO to extend their know-how jointly developed by them and Structural Engineering Research Centre, Roorkee, to all those parties who can take up the manufacture of deformed bars. This should of course be with the proviso that there will be no recurring foreign exchange requirements.

(e) While on the one hand the emphasis is on better quality of steel with high tensile strength, anomaly exists in the government policy that a large number of existing electric furnace units are not permitted to produce any steel other than mild steel. The Committee is of the view that such a restriction may be self defeating.

(f) High strength deformed bars with a proof stress of 50 kg/sq.mm are being produced in the country but the quantity is small. Increase in production of this type of bars may also be encouraged.

(g) There are indications from Bhilai Steel Plant that it will be possible for them to develop at short notice, say within a year, cold rolled deformed bars with a proof stress of 55 kg/sq.mm. This method of cold rolling will, however, be limited to bars of maximum diameter 12 mm. The advantage of this system is that it obviates the necessity for cold twisting. There will, of course, be need for installation of some plants and equipments. If the finished steel product can be sold at the same rate as that of cold twisted bars, manufacture of these bars in Bhilai Steel Plant is recommended.

5.6.2 High tensile steel wires.

A number of recommendations are based on the use of high tensile steel wires for prestressed concrete for various usages. Though high tensile steel wires are produced in the country, their production is insufficient. Non-availability or inadequate availability of such wires may pose one of the major bottlenecks in the substitution. This is traced back to the inadequate availability of high tensile, i.e., medium and high carbon wire rods. With a number of electric furnaces coming up, it should not be difficult to produce such wire rods, and increase their total output in the country. An anomaly exists in the Government policy that during the recent past a number of attractive proposals of those who can quickly take up the manufacture of medium and high carbon wire rods have not been favourably considered. Such wire rods technically are required to be in large weight and with a minimum inside diameter of the coil of about 750 mm and above. These are not capable of being produced by the ordinary mild steel re-rollers. The Committee recommends that Government may take necessary steps to augment adequately the capacity for the production of medium and high carbon wire rods in the country.. This needs to be pursued vigorously as this will help in substitution of pre-stressed concrete in place of steel in bridges and other structures, wherever they can be economically and advantageously used.

5.6.3 Semi-killed quality plates to IS:226.

If welded construction is to be adopted in a large scale for non-dynamically loaded structures, the present output of plates to IS:226 will have to be increased. Manufacture of killed quality of plates to IS:2062 required for dynamically loaded structures may be undertaken only as a long-term proposal.

5.6.4 Tubes, hollow sections and cold pressed sections.

Use of tubular construction is more efficient in utilisation of steel than other forms of fabricated steel structures. Stepping up the production of tubes and hollow sections and also increasing the number of rationalised sections, including larger diameter tubes is essential. Cold pressed steel sections are also very economical in the use of steel. Tubes and coldformed light gauge structurals require skelps and strips for their manufacture whose production will have to go up. Steel plants may also to examine the possibility of manufacture of hollow sections.

5.6.5 Bars re-rolled from rail and axle steels.

It is understood that a number of re-rollers do not get the required quantity of tested billets for production to their maximum installed capacity. In such cases, scrap rails and axles could be used for re-rolling into hot rolled deformed bars for reinforcement. A separate specification for this type of bar can be made by I.S.I. on the lines of A.S.T.M. specification. The Railways have already issued their own specifications for rolling plain bars from rail and axle steels and are getting such re-rolling done. The Railways are also considering manufacture of deformed bars from rail and axle steels. These specifications can also be adopted by I.S.I. Cold bending of these bars is not possible and heating is to be resorted to.

5.6.6 Light beam and channel sections.

Light beam and light channel sections standardised by the I.S.I. are more efficient in use of steel than medium and heavy sections. The Wanchoo Committee had recommended rationalisation of the following sections to start with :

ISLB 300	ISLC 300
ISLB 200	ISLC 200
ISLB 175	ISLC 150
ISLB 100	ISLC 125

These recommendations were made by the Committee in consultation with TISCO and Bhilai Steel Plant who had agreed to roll ISLB 100/ISLC 125 and ISLB 300/ISLC 300, respectively. There is an urgent need for J.P.C. to act upon these recommendations and arrange to include them in the list of rationalised sections. Unless these sections are rationalised, the designers will not adopt them in the designs and no demand can, therefore, generate although these are very economical in use of steel. In fact, it is understood that on the commitment made by Bhilai Steel Plant to the Wanchoo Committee, the Sales Department of H.S.L. tried to obtain orders for about 10,000 tonnes of the light beam and light channel profiles but they could not succeed. Consequently, rolling of these light sections could not be programmed by Bhilai Steel Plant. The Bhilai Steel Plant has indicated that it would be possible for it to develop these light sections if orders for a minimum quantity in consistency with economic rolling of these sections would be forthcoming. It should be possible for the other main producers also to undertake production of these light sections as the relaxations in the thickness of the web and the flange asked for by them have already been incorporated in the Indian Standards Specifications and there should be no practical difficulty in production.

5.6.7 "Nearly parallel" flange beams.

For the same geometrical properties, a parallel flange beam will weigh 5 to 7 per cent less than a sloping flange beam. In the context of steel economy, it is essential to switch over to the manufacture of parallel flange beams, as early as possible. Most of the more developed countries have already gone in for such beams. The manufacture of parallel flange beams, however, will require universal mills, which are not at present installed in any of the Indian Steel Plants. Hence, the proposal to go in for the manufacture of these cannot be implemented quickly and will necessarily have to be treated as a long-term one. The mills available in Bhilai Steel Plant, however, are suitable to produce "nearly parallel" flange beams. In fact, Bhilai Steel Plant had recently taken the initiative and made proposals for production of "nearly parallel" flange beams in lieu of the sloping flange ISMB 300. The proposals of Bhilai Steel Plant to go in for production of "nearly parallel" flange sections require to be encouraged so that gradually "nearly parallel" flange sections come into market for use substituting ISMB sections. Suitable standards to cover these products may be prepared by I.S.I. and J.P.C. may arrange to have them included in the list of rationalised sections.

5.6.8 Offgrade steel.

The Indian Standards Specification for structural steel to IS:226 was first issued in 1950 in response to requests made by steel manufacturers in this country. This specification was revised a number of times, the last one being in 1969. In its revision in 1962, only one standard quality of structural steel was included. Fusion welding quality structural steel was covered separately in IS:2062. It was observed then, that apart from steel being produced and marketed as conforming to IS:226, considerable quantity of steel produced fell outside the limits stated therein. A good proportion of this category of steel was being used in the structures with very liberal factors of safety, leading to undue wastage. In view of a number of representations made to the Indian Standards Institution, a separate standard IS:1977 was published in 1962 to cover steel falling outside the limits specified in IS:226 and which could be made good use of in many structures. This has enabled the products being sold as tested quality materials to this standard IS:1977. Two grades are prescribed in this standard, one which can be used for structures designed to carry stresses and the other intended for general purposes such as doors, window frames, window bars, fencing posts, etc. In the foreword of IS:1977-1962, it was stated that with the publication of that standard, in future, no steel would be labelled or marketed as untested.

Inspite of publishing a separate standard IS:1977-1962 for commercial quality steel in addition to IS:226, considerable quantity of steel structurals and plates produced are being marketed even at present as off-grade steel. J.P C. has also recognised this fact and has fixed the prices for their sale. The Committee fails to understand how, inspite of the facility given to have the offgrade materials got certified to IS:1977, the steel mills are producing structurals and plates which are falling short of even these relaxed specifications. Such offgrade steel is being necessarily put to wasteful use in structures by adoption of very low permissible stresses. This is a national loss. The Committee recommends that J.P.C. may not recognise such offgrade structurals and plates and should not publish prices therefor. The steel mills may produce generally structurals and plates to I.S. specifications only for sale within the country. In the interim period till sale of offgrade structurals and plates stops, to distinguish between the offgrade material and the material to standard specification, suitable colour code may be introduced.

All these references are with regard to finished steel products and not to semi-finished goods such as billets which could all get covered, probably, under the specification IS:1570-1961.

5.7 Production of cement.

In para 5.0.2, it has been brought out that if about a million tonnes of deformed bars are produced in the country per annum, this will make it possible for more of constructional work in RC to be undertaken to the tune of 33.33 per cent, making use of the 0.25 million tonnes of reinforcement thus saved. This will mean that consumption of cement will also increase to some extent. With the increase in production of cement being planned for in the country, making available this additional quantity of cement, it is expected, may not present a serious problem.

5.8 Production of bricks.

Since adoption of load bearing walls in buildings upto four storeyed construction require high strength bricks, it is necessary to develop this industry. The brick industry in the country is in the unorganised sector. It practices age old manufacturing methods which do not lend themselves to production of better quality and high standard bricks. The industry should be brought partially under the purview of the organised sector for scientific development, particularly in big cities in various states. Seven mechanised brick plants with the assistance of N.B.O. have been established in the country, 3 at Madras, one each at Delhi, Calcutta, Srinagar and in Assam and 8 more are proposed. One sand-lime brick plant is already established in Kerala while five more are proposed. The proposals to set up mechanised brick plants in Hyderabad, Bombay, Jammu, Bhuvaneshwar, Chandigarh, Vishakapatnam, Gauhati and Delhi and sand-lime brick plants at Indore, Hoshangabad, Jaipur, Nagpur and Hyderabad require to be pursued vigorously, to be followed by setting up more such plants in other major cities as well. This could be arranged by Ministry of Works and Housing in collaboration with State P.W.Ds.

5.9 Production of cellular blocks.

Since these materials are not possible to be transported in large quantities to longer distances, units will have to serve the requirements of an area of 70 to 80 km radius only. Two units have been set up at Ennore in Madras and in Poona with a capacity of 1,38,000 cu.m. and 70,000 cu.m., respectively.H.H.F. at Delhi also produces a small quantity. It is understood that there are proposals to set up plants at Bandel (West Bengal), Badarpur (Delhi), Bhatinda (Punjab), Kanpur and Bombay. There is scope for setting up a number of such units adjacent to thermal power plants where fly ash becomes available as a waste product from the thermal power plants. The Ministry of Industrial Development may coordinate and get more such plants installed, atleast near the areas where multi-storeyed constructions are coming into prominence.

5.10 Production of asphaltic corrugated roofing sheets.

Based on the scheme prepared by the National Buildings Organisation, two plants of total capacity 4 million sq.metres of asphaltic corrugated roofing sheets per annum have been set up at Madras and Tadimalla (Andhra Pradesh). There are proposals to set up 3 more plants, one each in Himachal Pradesh, Uttar Pradesh and Maharashtra. The progress of setting up of these plants is to be accelerated to enable reduction in consumption of corrugated GI sheets.

5.11 Production of welding consumables and welding equipment.

One of the measures that have been suggested for economy in consumption of steel is adoption of welded structures in preference to riveted ones. Manufacture of suitable welding equipment indigenously and stepping up production of welding consumables, such as, welding rods, wires, flux, etc., needs no emphasis. In this context, it has been brought to the notice of the Committee that there is delay in supply of the welding rods after their manufacture and this has been attributed to the present method of fixing the excise duty of welding rods as a percentage on value (ad valorem). The manufacturing firms are to wait for months before the evaluation is completed by the excise officials. This delay could be cut down if the excise duty is a fixed amount on weight basis or on length basis.

.12 Review and revision of codes.

Another direction in which economy in steel can be achieved is by adopting higher permissible stresses, reduction in load factors and downward revision in the standards for live loads and wind loads. Values of wind loads prescribed are definitely on the high side, when compared with the values adopted in different codes of foreign countries. While it may not be appropriate to straightway adopt the values prescribed in foreign codes without considering the modifications necessary for the Indian conditions, still there is scope for a review being conducted by the Indian Standards Institution to see whether any revision keeping in view economy in consumption of steel is possible, at the same time ensuring that a reasonably safe structure adopting realistic loadings is aimed at. Another point that can be examined by the Indian Standards Institution is whether the lap length prescribed for deformed bars can be reduced. I.S.I. may also consider prescribing provisions in the code for re-distribution of moments in RC rigid frames in addition to continuous beams and slabs, taking into consideration the latest provisions in British, American, Russian and other codes. IS:456 may have to provide for design of two-way slab by Hillerborg's strip method (modified). I.S.I. has formulated a code for use of structural aluminium in buildings. This may be finalised and issued early. Preparation of design handbooks, design aids and charts for popularising use of tubular sections, yield line theory/Hillerborg's strip method (modified) for design of RC slab, etc., may have to be undertaken by I.S.I. The Committee noted that the Railway Code for steel bridges has recently been revised, permitting higher stresses, in some cases than those allowed for structures in I.S.Codes. Railways are also taking action to modify the live loads, the impact loads and longitudinal forces adopted in design of bridges, after having conducted extensive trials with diesel and steam locomotives and new types of wagons, over period of nearly six years.

5.13 Conclusions.

5.13.1 Various short-term proposals have been made by the Committee after taking into consideration the practical aspects of their implementation within a short time and for this purpose the period for implementation has been assumed to be about 5 years. The Committee is convinced that there is a limit to the substitution of steel by other materials and this has been kept in view while recommending the use of substitute materials. Various other measures that have to be taken by the designers of civil engineering works have been dealt with in paras 5.0 to 5.6. Wherever possible, against each proposal, the approximate percentage of saving in steel that can be effected has been indicated. It is, however, to be clarified that the savings worked out are with reference to the conventional design procedures now in use. In many organisations, some of the methods suggested are already in use and in such cases, further saving that can be achieved may not be significant. In view of a number of variables involved, it is practically difficult to estimate with any degree of accuracy the overall saving in quantity that can be achieved. A rough assessment made, even on a very modest rate of percentage saving, shows that a reduction in consumption to the extent of about 0.47 million tonnes of steel per annum, with reference to the present level of consumption and production of steel in the country, can be anticipated, if all the recommendations made by the Committee in respect of civil engineering works are fully implemented, vide details given below :

Table III

S. No.	Short-term proposals contained in paragraphs No.	Category	Indigenous production in 1972-73 (Lakh tonnes).	Estimated quantity used in civil engg. works.	Percentage saving out of quantity in (5)	Reduction in consumption anticipated (Lakh tonnes).
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	5.1,5.4, 5.5.3,5.6.1, 5.6.2,5.6.5, 5.7 to 5.9, 5.12.	Bars and rods.	20.21	50% of (4)	25	2.53
2.	5.2 to 5.4, 5.6.3,5.6.4, 5.6.6 to 5.6.8, 5.11, 5.12.	Structurals.	8.54	50% of (4)	20	0.85
3.	-do-	Plates and sheets.	6.40	50% of (4)	20	0.64
4.	5.2.6,5.10.	Galvanised corrugated sheets.	0.93	100% of (4)	50	0.47
5.	5.5.1, 5.5.2.	Pipes.	-	1.00 lakh tonnes.	25	0.25
					Total:	4.74

5.13.2 As is well-known, with the rapid industrialisation in the country, the tempo of construction activity is bound to go up in the coming years and the extent of saving will also increase correspondingly. In the first 2 or 3 years, the saving will naturally be less than what has been indicated in the table, in view of the fact that various measures would be in different stages of implementation and only some of them would have been fully implemented. The Committee believes that if the measures recommended are adopted on a nation-wide basis, it will ensure that use and production of steel in the country as well as its import have been optimised and rationalised to a great extent, at least in regard to civil engineering construction.

5.13.3 The proposals contained are mostly pertaining to civil engineering works. The Committee could not go into the details and consumption pattern in other industries (except design and manufacture of railway wagons and coaches) and of alloy, special and tool steels. It is considered that there is scope for optimising production and use in these fields as well. Instituting separate investigations for the purpose may be justified.

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CHAPTER VI

OBSERVATIONS AND PROPOSALS FOR LONG-TERM IMPLEMENTATION

6.0 General.

6.0.1 In the large scale industrialisation and the developing economy of the country, demand for steel is going up. It is necessary that the advancement in technology in civil engineering constructional works elsewhere in the world should be adopted in India as well with a view to achieving efficient use of steel. Some of the measures which could possibly be implemented straightway have been indicated in the previous chapter and those measures should also be continued on a long-term basis. Besides, there are certain other fields of economy, the adoption of which may not be possible immediately, but require before their adoption, conducting of trials and development of new steels and substitute materials. The Committee recommends that although these have been brought under long-term proposals, the intention is that action should be initiated on these items also immediately. The results of economy in consumption can, however, be felt only after a considerable lapse of time.

6.0.2 Optimisation techniques.

Optimisation techniques for structural designs have become a standard practice in USA and other more advanced countries. There has, however, been very little progress made in India in this field. The Committee considers that reduction in consumption of steel and other building materials and consequent reduction in the total cost of works may be achieved, if the latest techniques in structural optimisation are applied.

6.0.3 Elimination of wastage.

Thorough planning should include detailing of steel components to minute detail which will avoid unnecessary handling and cutting of bars, plates and structurals. These will enable correct sizes and lengths of components to be ordered, wherever possible. Elimination of wasteful use of steel is also another direction in which there is considerable scope for economy in steel. Where a low grade material would serve the purpose of strength and durability that could be used in preference to steel. Even between one grade of steel and another, where a lower grade would suffice, use of that may be insisted upon.

6.0.4 It would be obvious, that the long-term proposals also need concerted action on all fronts, i.e., producers of steel and other substitute materials, designers, fabricators and the consumers. The proposals of the Committee in this regard are broadly brought out in the subsequent paragraphs.

6.1 Residential and office buildings.

Methods of achieving economy in the consumption of steel for buildings other than those which have already been indicated against short-term measures can be broadly classified as under:

(a) Use of substitute materials.

  (i) Use of very high yield strength deformed bars.

  (ii) Reduction in dead-load of the structural members by use of light weight structural concrete.

  (iii) Fibre glass for reinforcement.

  (iv) Use of secondary species of treated timber.

(b) Use of rational design methods such as limit state analysis combined with ultimate strength design for RC.

(c) Welding of reinforcement bars instead of lapping.

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Details of various methods enumerated above are briefly described in the following paragraphs:

6.1.1 Very high yield strength deformed bars.

Use of high grade steels as reinforcement in RC can lead to significant saving in steel. Cold twisted bars to IS: 1786 are of ordinary mild steel, with a high proof stress of 42.5 kg/sq.mm obtained by cold-twisting. Production of hot rolled deformed bars with a proof stress of 50 kg/sq.mm has been started in the country recently. Bhilai Steel Plant will be able to develop and manufacture cold rolled deformed bars of diameter upto 12 mm with a proof stress of 55 kg/sq.mm. These items have already been dealt with in the short-term proposals. It is possible to produce high yield strength deformed bars having a proof stress of upto 90 kg/sq.mm

Chemical composition of the material requires to be changed for the purpose. Some of the firms in India have plans to develop these grades of steel. These grades may require marginal import of additives. The efficacy in the use of these very high grade steels in RC and the associated problems of deflection, crack control, welding, increase in depth of construction, use of high grade concrete, etc., are not fully known. In the circumstances, the Committee considers that it would suffice if high strength bars of proof stress upto 60 kg/sq.mm are developed, provided there is no recurring expenditure in foreign exchange involved in the import of additives, however marginal and small the quantity may be.

6.1.2 Light weight structural concrete.

Light weight aggregate made out of expanded clay is being used for structural concrete in some countries. Their use in place of stone aggregates reduces the deadload of the structure. This concrete has also higher thermal insulation property. Consequent to the reduction of dead-load, about 10 to 15 per cent saving of steel can be effected with their adoption in RC frames for multistoreyed buildings. Manufacture of light weight aggregate has not yet been started in India and it requires to be developed on a priority basis. Light weight aggregate is also more useful specially in Gangetic plain where the availability of stone aggregate is poor and at present it has to be transported over long distances at great cost. Some cellular concrete products such as those by Siporex of Poona and Jayutan of the Hindustan Housing Factory, Delhi, can also be manufactured with reinforcing bars embedded. Although the maximum crushing strength of concrete that could be obtained so far is about 70 kg/sq.cm only, these are claimed to be suitable for use in floor and roof slabs as structural concrete elements. They weigh only about 1/4th of the weight of conventional RC of the same size, but thickness will have to be increased in case of cellular concrete structural slabs. These light weight cellular concrete reinforced slabs may also be made use of as an alternative to light weight structural concrete, where suitable.

6.1.3 Fibre glass for reinforcement in RC.

It is claimed that fibre glass could be excellent for services requiring high tensile strength, minimum weight, resistance to corrosion and resilience for resisting dynamic loads. The strength compares favourably with high strength steel, while it weighs only one-third. Recently, the use of fibre glass as reinforcement in concrete instead of steel has attracted the attention of engineers. The reinforcement requires a protective coating with resin to resist the corrosive attack of the alkali content in the cement mix. This coating improves the bond which is superior to that of plain bars. One limiting factor is the low modulus of elasticity of the fibre glass, being only 2 to 3 times that of concrete. This limits the tensile stress that can be transmitted from concrete to the fibre glass reinforcement. Currently, research is in progress on how to increase the modulus of elasticity of the glass so as to improve its performance as a reinforcement in concrete. Fibre glass is being produced in the country and has potential for replacing steel in reinforced concrete work. Although it is as yet premature to think of its large scale use in India for reinforcement in concrete, the need for its development exists.

6.1.4 Timber.

Timber can be utilized for a large number of structural uses where at present steel is being demanded. The expensive higher grades of timber which possess adequate strength as well as durability like deodar, teak, sal, etc., could be reserved for rational utilisation for permanent structures, which have to last for a very long time. In the case of rural houses, temporary and semi-permanent buildings, buildings in hilly areas and at higher altitude, low cost houses in urban areas, etc., the less-expensive secondary species of timber which have adequate strength and the durability of which could be improved by processing, could be utilised. Although seasoning is a "must" for all timber to be utilized, as regards the secondary species, it would be necessary, not only to season the timber but also to resort to suitable processes of wood preservation, so that wood may last for the intended life time of the structure. The necessary standards including a Code of Practice for its structural use in building (material, grading and designs), and for the seasoning and treatment of timber, are already available, having been issued by the Indian Standards Institution. But the utilisation of small dimensioned stock for building up bigger structures needs concerted promotion. Certain items like development of glued laminated wood, timber connectors for joints which are a source of weakness in timber structures, etc., are yet to make headway.

6.1.5 Limit state analysis for RC structures.

The present practice and the provision in I.S. Codes are that for RC framed structures, the analysis is done by elastic theory and the design done on ultimate strength. This takes into account the limited increase in the moment capacity of a RC structure due to development of plastic zone in concrete only. The effect of redistribution that takes place, which accounts for a major increase in the collapse load of the structure is not taken advantage of. To derive benefits that would accrue therefrom, limit state analysis will have to be adopted instead of the elastic analysis. It is recommended that the frame analysis for structures should be by this method only and incorporation of suitable provisions in the Codes and preparation of design aids may be undertaken by I.S.I. in collaboration with S.E.R.C. With this changed concept in analysis and design, some savings in consumption of steel can be obtained.

6.1.6 Welding of reinforcement bars instead of lapping.

There is much scope for reduction in the quantity of reinforcement steel if welding is adopted instead of lapping. An overall saving of about 5 per cent can be expected which can increase to about 15 per cent in columns of multistoreyed buildings. Effect of welding of cold twisted high strength bars of indigenous manufacture on their physical properties is to be studied. A technical panel of I.S.I. is already seized of the problem and are to make recommendations based on investigations to be done by independent organisations like S.E.R.C., R.D.S.O., etc. Based on the recommendations of this panel, I.S.I. may finalise the procedure to be followed and precautions to be taken for welding of cold twisted high strength bars of indigenous manufacture and issue an amendment to IS:456. In case of high strength deformed bars using alloy elements for getting higher strength, there may be practical problems in welding and trials in this regard may also be made by the S.E.R.C. and suitable recommendations given for incorporation in I.S.Code.

6.2 Structures.

6.2.1 Prestressed concrete and RC structures may be used, as far as possible. For situations where steel structures are unavoidable, economy in consumption of steel may be achieved by adopting methods described in paras 6.2.1 to 6.2.5.

6.2.1 High tensile steel.

Use of high tensile steel to IS:961-1962 is permissible in structures according to the code IS:800-1962. As the permissible working stress in tension is high, a saving of about 30 per cent in steel in members subject to axial tension should result. However, in axial compression, the percentage saving decreases with increase in the slenderness ratio and in the higher ranges there is practically no advantage between mild steel and HTS. In truss like structures, an overall saving of about 15 to 20 per cent can be anticipated with the use of high tensile steel, if the configuration is such that the slenderness ratio does not go beyond 140. Use of HTS in flanges of beams may lead to an overall saving of about 10 per cent if the beams are effectively braced in a lateral direction. Use of HTS is recommended in very tall towers for microwave and television antennae. Use of HTS can also be made in framed structures, effectively braced laterally, as in industrial buildings.

6.2.2 Weathering steel.

This is a low alloy high tensile steel and at present steel of this quality is not readily available in the country. TISCO have indicated that they can develop facilities for its production. It is claimed that this steel is free from corrosion and hence needs no painting Since the yield strength of this steel (32 kg/sq.mm) is almost the same as that of HTS, it can be used in all locations where use of high tensile steel has been recommended and the same extent of saving achieved. The additional advantage is that since there is no corrosion, the minimum thickness for any structure can be brought down without risk of corrosion failure and the section can be fully stressed to the permissible limit. There is also the indirect saving by way of prolonged life which these structures are likely to give with or without painting. Their use is particularly recommended in very high towers, which present problems of periodical painting. This type of steel has been used with great advantage in multistoreyed steel frames of very high rise buildings in foreign countries. The exposed steel frame is left without painting and un-encased and the brown adherent coating (or patina) formed in course of time is allowed to remain as an architectural treatment. A saving of 25 per cent in consumption of steel may be expected as compared to frames of mild steel. The manufacture of this weathering steel needs to be encouraged.

6.2.3 Welded Box girders.

Use of Box girders in steel structures has not come into much prominence in India. The main objection to their adoption, which involves use of thin sheets/plates is that the interior cannot be painted for protection from corrosion and their inspection is also not possible. Thus corrosion may go un-noticed. But with welded construction, box girders can be fully sealed and as such, should be free from internal corrosion, once the oxygen is used up. These designs are very economical in use of steel and have the advantage of high torsional rigidity. Their use is recommended in all medium and heavy industrial buildings for girders and columns.

6.2.4 Masts for railway electrification.

Either rolled beam sections or fabricated columns out of angles and plates are made use of at present in masts in Railway Electrification Works. Utilisation of tubular sections in place of the rolled sections, 6"x6" BFB and 8"x6" RSJ for OHE masts will result in about 30 per cent of the steel being conserved besides reducing the cost. Use of tubes in place of fabricated structure is not economical in consumption of steel. The design with tubes may be made from two lengths of different diameter. Since it may not be possible to restrict the deflection of the mast to the present prescribed limits, these will have to be relaxed. Use of prestressed precast concrete elements in electric transmission lines is in vogue in the country. Some preliminary designs made indicate that replacement of a steel OHE mast by a prestressed concrete one may lead to reduction in consumption of steel to the extent of about 70 per cent. These require proper quality control in their production, careful handling to avoid development of cracks and also rigid inspection during the manufacturing stage. Since use of these types of posts for railway electrification masts has not been resorted to in a large way elsewhere so far, extensive service trials for a reasonable period will have to be done before adopting them.

6.2.5 Steel plant structures.

In the more developed countries, steel consumption is of the order of 600 kg/head/year while the rate of consumption in India is only about 10 kg/head/year and is insignificant. India has, therefore, a long way to go in regard to production of steel. Setting up of new steel plants and increasing the capacity of existing plants will be a continuous process and the tempo of constructions is bound to increase in the coming years. It is estimated that for the construction of a two million tonne capacity integrated steel plant, about 1.5 lakh tonnes of structural steel work will be necessary. About 45-50 per cent of this structural steel work is consumed in crane gantry girders and columns in steel plant structures. There is, therefore, imperative need for rationalising the method of design of these crane gantry girders and columns, as any reduction in loads will result in considerable economy in the consumption of steel. The present provisions in the IS Code for impact, surge and longitudinal loads to be adopted in design of crane gantry girders and columns are rather empirical. It appears necessary to have investigations conducted to arrive at realistic values for these loads and based on the investigations, the IS codes could be modified. It is suggested that the Metallurgical and Engineering Consultants (India) Ltd., Ranchi may arrange for investigations to be done in this regard, compare with the practices followed by other countries and furnish necessary data to ISI for the revision of codes.

6.3 Highway bridges.

6.3.1 Prestressed concrete girders.

Prestressed concrete has been used in road bridges of spans upto 160m elsewhere in the world. The self weight of a prestressed girder introduces the limitation in its adoption for very long span bridges, as the self weight not only governs the design of superstructure but also the foundations and piers. If prestressed concrete is to be adopted for longer spans, use of very high strength concrete or light weight concrete may have to be resorted to or the girder should be in the form of a prestressed concrete truss. Development of concrete-polymer composites has established that very high strength concrete can be manufactured. Use of light weight structural concrete has also come into prominence and can be made use of though the compressive strength cannot go beyond what can be obtained with stone aggregates. Plants for manufacture of light weight aggregate are yet to be set up in the country. However, these are fields in which Ministry of Transport may have to take action in consultation with the Ministry of Industrial Development.

6.3.2 Steel box girders.

Box girder bridges are used as simply supported structures, as continuous ones, and as stiffening girders in the suspension system or in arch system. The sections may vary along the length of the bridge. Box girders have been used even in spans upto 1000 m viz. in Severn Suspension bridge, Great Britain. They are particularly adaptable to pre-fabrication and to the standardisation of details. Relatively large segments can be pre-fabricated, transported and erected with relative ease within a short time. They are suitable in curved geometric configurations as well. They are lighter than other bridges and this reduction is an advantage in long span bridges where dead weight of the girder if of concrete, steel or other forms of constructions will be very high. They are more streamlined and slender and have a pleasing appearance. The torsional rigidity is quite high and the girder can be of small depth where headroom is limited. Box configuration is economical in cost and in use of steel in very long span bridges combined with welding. A few recent cases of disasters and collapses of box girder bridges in U.K., Australia and Germany should not be a deterrent to their use in India. All these failures have been investigated in great detail and the design procedures have been modified which should result in safe structures. These have great potential for use in highway bridges and the Ministry of Transport may consider their adoption in long span road bridges

6.3.3 Cable stayed girders

In recent years, this new form of construction of steel bridges has emerged as an economical one for medium to long spans upto 600 metres. It is generally constructed as a deck bridge supported by inclined cables disposed eithe in a parallel arrangement or converging to a point. In the Second Hooghly Bridge at Calcutta this type of construction is proposed but with riveting. The cables are to be imported at a high cost. Maximum economy can be achieved if very high strength steel having a proof stress of 70 to 80 kg/sq.mm is used in combination with welding. It is necessary to develop and manufacture such high strength plates and structurals of weldable quality and the cables Its large scale use in highway bridges can be considered when these materials become available and the facilities for welding and their inspection improve in the country.

6.4 Railway bridges.

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Approximately, 40,000 tonnes of steel are used annually in railway bridge girder fabrication, out of which about 17,000 tonnes are imported. The possible ways of economising use of steel in railway bridges are enumerated below. Prestressed concrete/RC may be used as far as possible., Where this is not feasible, measures proposed in paras 6.4.1 to 6.4.6 may be followed.

6.4.1 High tensile steel.

The present practice of fabrication of bridge girders on Indian Railways is to adopt mild steel. Only in exceptional cases of long bridges, such as Ganga, Brahmaputra, Second Godavari and Krishna, HTS copper bearing quality has been used in the main girders to reduce the dead load of the span. The permissible working stresses in HTS to IS: 961-1962 are about 35 per cent more than those in mild steel, resulting in reduction in the quantity of steel consumed. In the case of plate girders, use of HTS is advantageous only in the flanges, as there is no economy achieved by its use in the web plates. Similar is the case with bracing system. An overall saving of about 10 per cent can be anticipated, if HTS is used partially in plate girders. The deflection of girders with HTS is likely to be high in open web girders and in some cases specific dispensation may have to be given. Such a dispensation was obtained for the long span bridges such as Ganga, Brahmaputra and Second Godavari. Although this increased deflection is not harmful for the present-day speeds upto 100 km/h, it may not be permissible with high speed operations of 160 km/h and above. Hence HTS girders of open web type cannot be adopted in those routes where speeds in excess of 160 km/h are contemplated. Use of HTS to IS: 961-1962 on open web girders can be adopted as a standard practice in other routes, but sufficient quantity of the steel has to be made available in the country.

6.4.2 Weathering steel.

Girders made of weathering steel which do not corrode are being utilized in bridges in foreign countries. Recently, M/s TISCO have intimated that they are in a position to manufacture weather resistant steel, which it is claimed by them is free from corrosion and hence will need no painting. This steel has a comparatively high yield value of 32 kg/sq.mm almost corresponding to HTS and hence higher permissible stresses can be allowed leading to a saving in steel of 7 to 20 per cent. It would be necessary to develop production of this quality of steel not only in the interest of economy in consumption of steel in the initial stages but also due to indirect saving by way of the prolonged life which this is likely to give with or without painting. The additional advantage is that since there is no corrosion, the codal provisions for the minimum section for bridge girders can be brought down to 6 mm. This may further increase the extent of saving that can be obtained. Use of this steel appears to be a better alternative to HTS both for plate girders and open web girders and hence is recommended. It is noted that the Railway Board have already ordered trials with four 12m span BGML girders and the materials are being procured from M/s TISCO. Based on these trials, its use can be extended.

6.4.3 Welded girders.

Adoption of welding in railway bridge girders, which at present is of the riveted type, is recommended. This is likely to result in a saving of around 15 per cent in steel. Being a dynamically loaded structure, steel used is to be of killed type to IS: 2062-1969. Welded plate girders make use of only plates. The present indigenous production of steel to IS: 2062 is insignificant and special arrangements will have to be made to produce steel plates to IS: 2062-69 in sufficient quantity before welding of railway bridges can be undertaken. Welded girders of the open web type can also be adopted. The floor system can be of box section and welded separately. Site connections have to be riveted or of friction grip fasteners. With the complete change over of riveted construction to welded construction in railway bridges, which consume about 40 thousand tonnes of steel per annum, a reduction in consumption of the order of 10 thousand tonnes may be anticipated. This, however, requires augmentation of the fabricating facilities in the country. Installation of automatic equipment and efficient training of welders are essential. Adequate radiographic inspection equipments are also to be installed, to ensure that the weld is sound. Electrodes, the filler wire and flux have to be produced in sufficient quantities in the country.

6.4.4 Box girders.

Welded box type of girders if adopted for railway bridges may result in considerable saving in steel. There are, however, numerous problems met with in the design, fabrication, erection and maintenance. Indian Railways may have to develop considerable expertise in this field. It is claimed by Japan who have a number of box girders in railway bridges, that from the economic point of view, box section railway girders prove to be superior in the range of spans greater than 30m only.

6.4.5 Orthotropic plate construction.

This is a multiweb structure developed to provide a single span bridge with maximum under clearance and with a minimum raising of track and no side clearance restrictions. The design is unique in that the top plates serve a number of functions, viz., as the top flange of main girders, as the top flange of diaphragms, as deck plates and as the lateral bracing system. Side plates can be added to the deck plate to retain the ballast. This is suitable for design as continuous structure as well. Orthotropic plate floor system can also be used in through girder spans with high strength friction grip fasteners or rivets connecting them to the main girders. This offers a great potential for use in railway bridge girders with great economy in steel used when welding can be adopted.

6.4.6 Continuous girders.

Tentative designs of continuous girders in steel made by R.D.S.O. indicate that some saving in the quantity of steel may be achieved by making the girders continuous instead of adopting the congentional simply supported span. In plate girder spans, the reduction in weight would be around 7 to 8 per cent compared to simply supported riveted girders. One design of the open web type made by R.D.S.O. shows the extent of saving to be only about 5 per cent. In Japan, a large number of continuous girder bridges in steel are in use. It is claimed by them that adoption of a 4 span continuous box type steel girder has resulted in a saving of 13 per cent in weight of steel compared to the simple box girders, while a 3 x 60m span open web continuous girder bridge had brought a saving of 8 per cent in steel. Besides the economy in consumption of steel that can be obtained some incidental advantages of continuous span are as under:-

(a) It is convenient for cantilever erection method and hence the erection work can be carried out in any season of the year.

(b) It gives better riding to the vehicles because the deflection angle of the girder over the intermediate piers is smoothened.

Adoption of continuous girders will require utmost care in the fabrication and erection. A special watch has to be kept on the levels of these bridges to see that during floods, there is no settlement due to scour. Effect of settlement during earthquake will also be another problem that may have to be considered. Hence for introduction of continuous girders, the expertise is to be developed in India. This type of girder is suitable only in new constructions or doubling and not for regirdering of existing bridges.

6.4.7 Prestressed concrete girders.

The suitability of prestressed concrete for railway bridges is proved by its successful use on heavily used main lines in U.K. and Japan. Although the initial cost may not always show a saving, the capitalised reduced future maintenance cost is usually less. Prestressed concrete girders can be of semi-through type where there are limitations on the depth of girder. These could be adopted for spans upto 46m in new constructions and doublings. Suitable designs for precast elements for prestressed concrete girders may be evolved so that these girders can be used as well for regirdering of existing bridges.

Box girders of prestressed concrete may also be adopted in longer spans to achieve economy in the use of steel. They are eminently suitable for ballasted viaducts and the elevated structures for Metropolitan Transport Project (Railways) which are due to come in future.

6.4.8 Use of deformed bars.

In view of the uncertain fatigue properties of RC members having deformed bars as reinforcement, these were not allowed in railway bridges till recently. But now their use is permitted but the permissible stresses in reinforcement are not much different from those for plain M.S. bars. Tests were being conducted by SERC/Roorkee, but the results so far have been inconclusive. Independent study is proposed to be conducted by the R.D.S.O. as well to expedite matters. The Railways may have these studies done early to allow higher permissible stresses with deformed bar to take advantage of its strength. A saving in steel to the extent of 25 per cent can result, even if the permissible stress is increased to 9 kg/sq.mm.

6.4.9 Use of aluminium alloys.

Aluminium alloys with 0.1 per cent proof stress comparable to the yield value of mild steel have become available in the country. Some of the fields where this has potential for application are as under:

(a) Replacement of the decks of existing long span bridges which are inadequate in strength for the current loadings. The deadload reduced may overcome the necessity for replacement, or strengthening of the main girders and permit relaxation of removal of the restriction in speed.

(b) Emergency girders where time factor and light weight are important.

(c) Launching girders in the erection of bridge girders of prestressed concrete or steel.

(d) Continuous girders in permanent installations.

One of the disadvantage of aluminium alloy, if used for bridge girders is that its E value is only 1/3rd of that of steel and hence deflection would be considerably higher. Perhaps, this draw-back could be overcome if in permanent installations, adoption of continous girders is thought of. In the case of emergency girders and launching girders, the high deflection itself cannot be treated as a serious problem to be tackled. In temporary constructions, the speeds are low and such high deflections can be allowed. Another disadvantage is that the temperature movements of the girder are likely to be about twice that of steel structures and this aspect has to be taken care of in permanent installations. That the aluminium alloys will not require any maintenance by way of painting is an advantageous factor. Use of aluminium alloys in railway bridge girders is only a distant possibility when the country produces sufficient quantity of structural grade alloy.

6.5 Railway track.

The demand of rails on the Indian Railways is of the order of 3 lakh tonnes per annum, the bulk of which consists of 52 kg and 90R rails. Roughly one lakh tonnes of these rails are utilized for new works and the balance of 2 lakh tonnes in replacements. Nearly 4,500 tonnes of steel is used in fishplates and about 1500 tonnes in fishbolts and nuts. The annual procurement of steel trough sleepers at present is 6 lakhs in number which need 50,000 tonnes of steel. The mild steel fittings and tie bars which go with CST-9 sleepers and wooden sleepers account for nearly 40,000 tonnes. Thus the total requirement of steel for permanent way materials is around 4 lakh tonnes per annum. Considering the total length of nearly one lakh kilometres on Indian Railways having 9 million tonnes of rails in the track, this annual demand is considered quite reasonable. In fact, it is the lowest among the Railways in the world. However, further economy can be effected by improving the metallurgy of rail steel and by adopting improved track structure and techniques of maintenance and better methods of repairs and reconditioning as also by large scale reclamation of worn out materials, which are dealt with in subsequent paragraphs. Incidentally, it is to be pointed out that indigenous capacity for production of rails is more than the demand and there is surplus capacity available which is being utilized for export.

6.5.1 Rails.

6.5.1.1 Wear resistant rails.

While the medium manganese rails with an ultimate strength of 72 kg/sq.mm can withstand the stresses created by the normal types of locomotives and rolling stock in operation at present, the special rolling stock with higher axle loads and smaller diameter wheels and more powerful locomotives contemplated for the future would require rail steel of higher strength. The effect of higher axle loads and smaller diameter of the special type of rolling stock like BOY, BOBS wagons, etc., would be most severe on ghat sections having steep gradients and sharp curves. The 44 Km long line from Waltair to Kirandul on the South Eastern

Railway is a typical example of such cases. This line was opened for carrying iron ore traffic from Bailadilla mines to Visakhapatnam Port in 1966-67 and within 4 years of its opening it was found that 90 lb. medium manganese rails used on the ghat sections had become unservicable and required immediate replacement.

While the ghat section of the Waltair-Kirandul line is an example of the extreme limit of heavily graded and curved sections, there are about 2000 km of track on Indian Railways with sharp curves varying from 3° to 8°. Due to heavy wear on the curves, these stretches of track require renewals at very frequent intervals ranging from 5 to 15 years. The solution to this problem lies in the use of special alloy steel rails with higher percentage of manganese and wear resistant qualities. The Continental Railways have already developed wear resistant rails having an ultimate tensile strength of 90 kg/sq.mm and minimum elongation of 10 per cent. This has been achieved by improvement in the metallurgy of the metal as can be seen from chemical composition indicated below:

Table IV

Quality		C %	Mn%	Si % max.	P % max.	S % max.
Special wear resisting quality.						
UIC grade 'A'	..	0.60-0.75	0.30-1.30	0.50	0.05	0.05
" 'B'	..	0.50-0.70	1.30-1.70	0.50	0.05	0.05
" 'C'	..	0.45-0.65	1.70-2.10	0.40	0.03	0.03

While the wear resistant rails to UIC grade 'A', grade 'B' and grade 'C' have been commonly used on the Continental Railways to overcome the problems of rail wear on sharp curves and steep gradients, extensive trials have also been conducted on Swiss Railways with high manganese British Hadfield rails with 11 to 13 per cent manganese and chrome manganese rails which are very near to UIC grade 'C' rails but are alloyed with additional elements like chromium, vanadium and molybdenum. Indian Railways have already provided for trials with UIC grade 'B' and grade 'C' rails. HSL have manufactured some quantity of grade 'B' rails while grade 'C' rails are being imported from Germany as HSL had expressed their inability to develop production of grade 'C' rails for the present. Grade 'C' rails are not easily weldable and hence they are not suitable for use in welded track. Use of grade 'C' rails may, therefore, have to be restricted to sharp curves where welding of rails is at present prohibited. On the other hand, grade and 'B' rails can be used in curves as well as in straight with welding. It would be necessary to go in for high strength rails in all trunk routes and main lines because of the increased axle loads of wagons and higher density of traffic. Since hard core routes are progressively laid with long welded rails, grades 'A' and 'B' rails which are weldable and are of higher U.T.S. than the present medium manganese rails, have a greater potential for use in these routes. The demand for grades 'A' and 'B' rails is, therefore, likely to be considerably more than that of grade 'C' in course of time. German Federal Railways, of late, have shown a preference for UIC grade 'A' rails over grade 'B' from the point of view of easy weldability without significant reduction in wear resistant properties. On these considerations, it is desirable to develop production of grades 'A' and 'B' rails indigenously rather than grade 'C'. Chrome-manganese rails have a still higher U.T.S. of 110 kg/sq.mm with better weldable and wear resistant properties. These rails would, therefore, be ideal for use in special locations such as points and crossings, curves in heavy mineral lines, heavily graded sections, etc. Their development and production, if comparatively easier, are also recommended in preference to that of grade 'C' rails.

Manufacture of Hadfield manganese steel rails will present difficulties. They are not easily weldable. They pose problems in machining, drilling, etc. Hence, its development for the present is not advisable.

6.5.1.2 Corrosion resistant rails.

There is also a great scope for the development of a suitable alloy rail steel to resist corrosion. On the Indian Railways there are about 1650 Km of track which fall in corrosive areas requiring frequent rail renewals. Of these, about 220 Km require rail renewals within 5 years, about 510 Km within 5 to 10 years and another 920 Km within 10 to 15 years. So far there has been no development of corrosion resistant rails but the problem of corrosion is being tackled by all the Railways by painting rails with corrosion resistant bituminous paints. It is, therefore, necessary to investigate the possibility of developing a suitable alloy rail steel to resist corrosion effectively.

If we can successfully develop suitable corrosion resistant alloy rails, it should be possible to bring about an economy of 10,000 tonnes of rails every year on this account.

6.5.1.3 Volume hardened rails.

In the Soviet Union, rails are being volume hardened and tempered for improving the service life under more intensive utilisation. There is need for investigations to be initiated to establish the techno-economic viability of this proposal. This may need elaborate arrangements to be provided even at the experimental stage but is worth considering.

6.5.1.4 End hardened rails.

In long welded rails there is very little need for end hardened rails. These may be necessary only in short welded panels and the quantity required will not be considerable. A small quantity of such rails had already been manufactured by HSL and trials are proposed to be conducted with them.

6.5.1.5 Improved track structure and elimination of rail joints by welding.

Modern track structure consists of continuously welded rails laid with elastic fastenings, rubber pads, etc. Elimination of rail joints goes a long way in increasing the service life of the rails because the presence of rail joints causes excessive fatigue in the rails and diminishes their service life. The experience abroad shows that by adopting long/continuous welding of rails the service life of rails can be increased by 30 to 40 per cent. At the same time there can be substantial economy in fuel consumption, reduction in wear and tear of rolling stock, extension of sleeper life and saving in the cost of track maintenance. Indian Railways propose to lay long welded rails/continuous welded rails on their hard core routes totalling to about 25,000 track Km. Assuming the average life of rails in service as 25 years, the annual requirements of rails for hard core routes would be 1.1 lakh tonnes. With even 25 per cent increase in life of rails after they are welded, the annual saving of rail steel would amount to about 27,500 tonnes.

6.5.1.6 Improved repairs and reconditioning of track components.

There are many methods of carrying out repairs and reconditioning of track components such as in-situ welding of battered rail ends, lubrication of rails on curves, etc. Reconditioning of points and crossings by welding has shown a great potentiality for economy in rail steel. On an average, about 10,000 tonnes of rail steel is consumed annually in manufacture of points and crossings. By adopting reconditioning of points and crossings by in-situ repair welding on a large scale, it should be possible to bring down the consumption of rail steel for points and crossings by 50 per cent, i.e., 5000 tonnes per annum can be economised. It has also been decided by the Railway Board that as a matter of policy use of cast manganese steel crossings with manganese content of 12 to 14 per cent be made on all high speed routes. This is expected to give a large service life of crossings and it may be possible to achieve a further saving of about 1000 tonnes of rails per annum

6.5.1.7 Re-use of released rails in track.

At present primary renewals to the extent of 1200 track km in BG and 350 track km in MG are being carried out annually. Substantial economy in the use of rail steel can be achieved by using techniques followed abroad for reclaiming released rails. These techniques include ultrasonic testing for their classification into various usable categories, end cropping of defective rail ends, welding them to form long rails and finally re-profiling to get correct table top and gauge face. The rails which have still sufficient residual fatigue life left in them can be re-used in the track itself. Even assuming that only 50 per cent of the rails released are found suitable for re-use in track, the requirement of new steel rails can be curtailed substantially. For adoption of this technique, however, installation of ultrasonic testing devices and rail re-profiling machines is necessary. A techno-economic study of the process is also suggested.

6.5.1.8 From what is stated in the foregoing paragraphs it may be seen that economy in steel can be effected to the extent shown below:

(a) By developing wear resistant rail	..	10,000 tonnes
(b) By developing corrosion resistant rails	..	10,000 "
(c) By adopting long welded rails	..	27,500 "
(d) Reconditioning of points and crossings by welding.	..	5,000 "
(e) By use of CMS crossings	..	1,000 "
(d) Miscellaneous	..	5,000 "
	Total	58,500 tonnes
	Say -	60,000 tonnes

This saving will, to some extent, be offset by increase in the demand due to increased tempo of construction, doubling and conversion projects, etc., the growth in originating traffic as also due to the introduction of more powerful locomotives, higher axle loads and faster trains.

6.5.2 Track fittings.

The demand for fishplates is likely to come down progressively due to large scale introduction of welding of rail joints and laying of long welded and continuous welded rails. The demand for fishplates for 52 kg rails particularly would be substantially reduced. Trials are now being carried out in use of smaller diameter bolts and nuts and if this proves successful, the problem of shortage of IRS T-23 billets for bolts and nuts will be solved and there will also be sizable economy in the use of steel apart from the technical advantages.

6.5.2.1 Reclamation of track fittings.

Track fittings such as fishplates, tie-bars, screw spikes, etc., can be reclaimed by carrying out certain repairs such as re-pressing of fishplates, conversion of scrap/BG tie-bars into MG ones, forging and rethreading of screw spikes, etc. By these means significant saving in steel used for manufacture of such small fittings can be achieved. Released steel trough sleepers from BG can also be cut, repaired and reused in MG.

6.5.3 Sleepers.

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Considerable quantities of steel and cast iron are consumed in the manufacture of CST9 and steel trough sleepers. It has been decided to use concrete sleepers on all the important trunk routes of the BG with a kilometrage of about 25,000. If prestressed concrete sleepers are adopted and if one million number of these sleepers are produced in India per annum the intake of CST9 sleepers can be curtailed to that extent on BG, which may result in economy of about 6,000 tonnes of mild steel and about 64,000 tonnes of cast iron. If the manufacture of prestressed concrete sleepers of the type mentioned above can be stepped up to 1.5 million numbers per year the intake of steel trough sleepers can also be reduced proportionately resulting in a further saving of steel to the extent of 36,000 tonnes.

The life of concrete sleepers with elastic fastenings is considerably longer than that of CST9 sleepers and steel trough sleepers. It is roughly estimated that the life of concrete sleepers is about twice that of CST9 sleepers and 1½ times that of steel trough sleepers. In view of this, with the use of 1.5 million concrete sleepers, the annual requirement of sleepers will come down by 30 to 40 per cent and as a result of which there will be further saving in the consumption of steel in the manufacture of sleepers. The additional savings on this account will be about 6,000 tonnes of steel per annum.

From what is stated above, it may be seen that 6,000 tonnes of mild steel and 64,000 tonnes of cast iron can be saved by stepping up production of prestressed concrete sleepers to one million numbers per year in the initial stage and curtailing the intake of CST9 sleepers to that extent. A further saving of 36,000 tonnes of mild steel can be achieved if the production of prestressed concrete sleepers is increased by another 5 lakh numbers per year with the anticipated increase in life of prestressed concrete sleepers, the intake of sleepers can be reduced at a later stage by 30 per cent to 40 per cent if prestressed concrete sleepers are adopted which will result in a further saving of about 6,000 tonnes of mild steel per year

The above figures of likely economy is steel due to use of concrete sleepers can be realised only as a long-term measure. As a short-term measure it may not be possible to achieve significant economy in the consumption of steel in sleepers because even with progressively larger utilisation of concrete sleepers in the years to come, there will be no economy as the demand for sleepers is likely to go up due to the fact that in the 15 years corporate plan period it is proposed to increase the quantum of primary renewals from 1200 km per annum to 1600 km per annum thereby registering an annual increase in demand of sleepers of the order of 400 track km per annum. However, in case the track renewals are carried out at the present level of 1200 track km per annum and concrete sleepers are increasingly utilised then the economy forecast above can be effected gradually. Use of RC two-block sleepers involves increased consumption of steel and their use may not be advantageous in the context of economy in steel.

6.6 Railway wagons.

Wagon manufacture consumes about 1.25 lakh tonnes of steel per annum, out of which about 30,000 tonnes are imported, mostly in the form of plates. This requirement is likely to go up with the possible increase in number of wagons required in the Fifth Five Year Plan to handle the anticipated increase in traffic particularly coal. Various possibilities of reducing the use of steel in wagon manufacture and its maintenance are discussed below.

6.6.1 Welded construction.

Welded fabrication is lighter compared to riveted fabrication and in the recent past, taking advantage of the development in welding technology, riveted joints are being gradually replaced by welded joints in wagon body. The change-over has to be effected gradually as, apart from other considerations, care has to be taken to ensure that the torsional stiffness is in no way increased in view of the attendant undesirable effects. Yet, another factor which necessitates a cautious approach in the matter is the adverse effect on fatigue strength of a welded joint vis-a-vis riveted joint.

6.6.2 Special wagons.

It is needless to mention that designing wagons for the transport of specific commodities would permit the optimum design being evolved, leading to the use of minimum quantity of steel. Wagon designed for the transport of iron ore is an example of this type and benefit of such a design with optimum use of steel could be availed of by identifying streams of traffic which concern specific commodities and operate in a close circuit.

6.6.3 Centre buffer couplers (CBC).

The provision of screw coupling or transition type coupling necessitates fitment of side buffers and diagonals for transmitting the stresses. With the adoption of CBC the need for fitment of side buffers and diagonals would cease leading to a saving in consumption of steel. The change-over to CBC as a standard is of course dependent on the augmenting of indigenous capacity for manufacture of steel castings required. It would not be out of place to mention that at present the indigenous capacity is limited.

6.6.4 Pressed sections.

In the case of riveted designs evolved in the past, a review made has revealed that certain fabrications involving rolled sections could be substituted by 'pressed sections' with reduction in the consumption of steel. This exercise is in hand and the advantages offered will be availed of.

6.6.5 Better quality steel.

Copper-bearing steel, which has inherent corrosion resistance has been prescribed for wagon construction, but due to its not being available indigenously, non-copper-bearing steel is being used. Apart from lacking inherent corrosion resistance, mild steel also suffers from lack of abrasion resistance. In as much as the interior of the sides, ends and floor of wagons is exposed to both corrosion and abrasion, using steel which has both corrosion and abrasion resistance would go a long way in prolonging the service life. There are certain low alloy steels which apart from possessing inherent corrosion and abrasion resistance, also possess higher tensile strength compared to mild steel and thus permit thinner sections being utilized for bearing the same stress levels. The use of low alloy high-yield steels for wagon construction could lead to a saving of nearly 10 per cent in the consumption of steel. Change in design could, however, be effected only when the special quality steel referred to becomes available in adequate quantities both for manufacture and maintenance. Adoption of this type of steel for 'patches' put on and structurals replaced during repairs in the case of wagons in service, will also bring down the maintenance requirements of steel.

6.6.6 Aluminium.

Suitability of aluminium for wagon construction has not yet been established. Use of aluminium for construction of body of hopper wagons was tried, but given up as it was found to be unsuitable. Consequently, it is not opportune to consider the use of aluminium for wagon construction at this stage.

6.6.7 Fibreglass reinforced plastic.

Trials have been made in foreign countries with barrels of tank wagons moulded from fibreglass reinforced plastic,but it [illegible] considered suitable for adoption in India at the present juncture when we do not have efficient mechanical retarders in all hump yards. Utility of reinforced plastics for smaller components such as vacuum cylinder, guide-bush, brake gear bush, valve seatings, etc., is being tried.

6.6.8 Rubber.

Rubber pads are being used in lieu of helical springs in side-buffers and to that extent in can be said that rubber has already replaced steel. Patented rubber springs are being tried out in countries abroad in lieu of steel springs at other locations but adoption of the same in India would of course have to pend till the indigenous development of such a material.

6.6.9 Cast steel bogies.

Past experience has shown that adopting a bogie of cast steel, in preference to a bogie fabricated from plate sections would lead to a reduction in the consumption of steel. For various reasons, cast steel bogie is likely to be adopted as the standard for bogie stock on Indian Railways and, therefore, the economy in consumption offered would be availed of.

6.7 Railway coaches.

The approximate requirements of steel for the manufacture of new coaches is 50,000 tonnes per annum. Mainly steel sheets, plates and rolled sections are utilized for the manufacture of new coaches produced in the country. Besides requirement of steel for new construction, some quantity is required by the workshops for maintenance purposes. The total requirements of the steel are partly met by imports and partly from the steel mills in the country almost equally. Some of the means which could be adopted for effecting economy in steel consumption are as follows:

6.7.1 Use of longer coaches and double deck coaches.

The weight of the III class all-steel integral coaches built by Integral Coach Factory and Bharat Earth Movers Ltd., is approximately 39 tonnes, with a seating capacity for 80-90 passengers. An increase in the seating capacity can be obtained by developing double deck coaches and 23.2m long coaches in lieu of the present 21.4m long coaches. The increase in the weight of these coaches would be pro rata less than the percentage increase in carrying capacity. Rough estimate shows that the increase in tare weight and corresponding increase in carrying capacity for longer coaches and double deck coaches would be as under:

Longer coaches.

Increase in the tare weight	.. 5.3 per cent.
Increase in the carrying capacity	.. 11 per cent.

Double deck coaches.

Increase in the tare weight	.. 10.6 per cent.
Increase in the carrying capacity	.. 60 per cent.

Thus, with introduction of longer coaches and double deck coaches in large number on Indian Railways, there will be substantial reduction in the quantity of steel used for coach construction. The design of double deck coach has already been developed and orders have been placed on Integral Coach Factory, Perambur, for the manufacture of 3 prototype coaches to assess passenger reaction. Designs of longer coaches have also been developed. Based on the trials, their use can be extended.

6.7.2 Use of plastic items.

There are many fittings in the coaches which are manufactured from steel. There is considerable scope for replacing such items by fibreglass reinforced plastics (FRP) and plastic items. In fact, trials with FRP and plastic items are in progress and it is expected that in the years to come, many of the steel fittings in the coaching stock may be replaced by FRP and plastic items.

6.7.3 Use of aluminium.

In the context of reducing the tare weight of coaches, it is proposed to develop aluminium coaches. Such coaches will also offer better resistance to atmospheric corrosion. With the introduction of such coaches in larger number, substantial saving in steel can be achieved. Considerable development work in consultation with Industry will have to be done before suitable designs are evolved. It is expected that development work will take about 5 to 7 years.

6.7.4 Use of peeled and centreless ground steel rods for springs.

For obtaining optimum service life of suspension springs, it is necessary that they are manufactured out of peeled and centreless ground steel rods. However, some proportion of springs are still manufactured from hot rolled bars due to lack of facilities for peeling and centreless grinding in some of the private sector firms manufacturing coil springs. The installation of these facilities in all the manufacturing units will assist in increased service life and utlimate reduction in the consumption of spring steel rods.

6.7.5 Use of corrosion-resistant steel and use of coach shell with centre-sill type construction.

In spite of surface preparation and protective treatment to steel members, it has not been possible to combat corrosion on all-steel coaches and this results in heavy rehabilitation repairs after a service period 7 to 10 years. Considerable quantity of steel is thus used by the workshops for repair works. In order to obtain corrosion-free performance, it is necessary that the steel used for coach construction has in-built corrosion-resistant properties. In this context, it is desirable to use 'low alloy, high tensile' steel for coach construction in lieu of the existing copper-bearing mild steel'. Owing to the superior corrosion-resistant properties, it is expected that the coaches made of this steel would have increased service life. This type of steel is, however, not being produced indigenously. It is necessary that facilities are developed in the country for its manufacture.

A change in the design of coach shell so as to eliminate the corrugated trough floor, on which bulk of corrosion effect is felt, appears necessary. Such a design, in fact, has already been evolved in R.D.S.O. and prototype production and stress exploration tests planned. In conjunction with the use of 'low alloy high tensile steel', this design is expected to yield much superior service performance. With the introduction of coaches of this design, considerable saving in the steel used for repair work can be achieved.

6.7.6 Use of wear-resistant wheels and tyres.

Presently, the wheels and tyres used for main line coaches have tensile strength of 78 to 90 kg/sq.mm. The approximate life of a solid wheel before it is due for retyring is 10 years. The approximate life expectancy of a tyred wheel is 7 years. The life expectancy could be further increased by the use of high tensile steel with better wear-resistant properties. Such wheels and tyres, however, are not being produced in the country. Creation of facilities for production of tyres and wheels with better wear-resisting properties can bring about some reduction in consumption of steel. However, before adoption of wheels and tyres with better wear-resistant properties, the effect of such wheels on the rails will have to be assessed.

6.8 Improved maintenance practices.

It has been estimated that due to corrosion alone, there is loss of about Rs. 150 crores a year in the country, out of which the railways account for Rs. 20 crores. Intensification of measures to protect ordinary steel against corrosion needs attention as this will prolong the life of the steel members and thereby indirectly reduce consumption of steel required for repairs and replacement.

6.8.1 Better surface preparation.

For painting systems to be effective, proper surface preparation is essential. Cleaning with wire brushes is not quite satisfactory. In important structures, bridge girders and wagons better surface preparation with grit/sand blasting for cleaning of the surfaces shall be followed as far as possible. As some of the surfaces cannot be accessible after fabrication, surface preparation and application of primer should preferably be done in the initial stage itself. Before these processes are adopted on a large scale, it would be necessary to augment the indigenous capacity for manufacture of the blasting equipment required and steel grit. The workshops in charge of steel fabrication will also require the additional facilities to be set up.

6.8.2 Painting systems.

Till a few years back red lead was invariably used as a primer for new steel structures. This is, however, not proved to be satisfactory in the coastal regions. Besides, use of red lead involves import of raw materials. To avoid this, various combinations of paints were tried on the Railways. The alternative of one coat of zinc chromate primer followed by one coat of zinc chromate red oxide with 2 coats of aluminium painting has proved to be satisfactory in non-coastal areas, provided surface preparation is better.

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6.8.3 Metallising (aluminium or zinc spraying).

In the coastal regions the painting systems using red lead or zinc chromate as primer are not proving satisfactory for a long period. Trials conducted by the Railways in Pamban Viaduct indicate that the best long-term solution appears to be metallising the girders with sprayed aluminium followed by painting. This also requires surface preparation with sand/grit blasting. Calculations made indicate that the annual cost of service on aluminised girders is the lowest for use in coastal region. Metallising with sprayed zinc had also been tried, but it has been observed that the performance of sprayed aluminium is superior.

6.8.4 Galvanising.

Galvanising of structures which are difficult to paint, is an alternative to metallising but this requires zinc which will necessarily have to be imported. Hence galvanising as a method of protection of structures may have to be restricted. Further galvanising is not likely to be suitable for bridge girders and other dynamically loaded structures for the following reasons:

(a) Galvanising requires pickling, with proper inhibitors. If this is not properly done the girders may absorb hydrogen and this may lead to hydrogen embrittlement. This is not a desirable feature in structures subjected to dynamic loading.

(b) The process of hot dip galvanising introduces a brittle inter-metallic layer which again is a disadvantage in dynamically loaded structures, such as railway bridge girders.

6.9 Use of scrap axles, wheels and tyres.

Indian Railways have sufficient arisings of scrap axles and tyres. The material used for manufacture of axles is forging quality steel which is in short supply in the country. The axles are scrapped in service either due to wearing beyond condemning limits or due to failure in service. Axles rejected due to former reason which are metallurgically sound can advantageously be re-used for the manufacture of some components such as equalising beams of MG coaches, MG and NG axles for locomotive coaches and about 45 carriage and wagon components. With judicious use of such axles for the manufacture of these components, economy in consumption of steel in the country can be achieved.

Similarly, scrap loco carriage and wagon tyres falling within the carbon range stipulated for carbon spring steel could be advantageously rolled into spring steel flats and used. Tyres containing carbon of 0.60 to 0.75 per cent could be advantageously used for the manufacture of hand tools.

The above mentioned measures are already in vogue in the Railways.

In addition to effecting economy in utilisation of scrap arisings as mentioned above sufficient economy in the consumption of tyres and wheels could be achieved by re-conditioning of the worn-out portions with submerged arc welding. The loss of metal due to wear between rails and wheels/tyres is perhaps the most expensive loss to the Railways from a single factor. During service, flanges of rolling stock wheels/tyres wear out more at tread portions resulting in formation of thin flange. In the case of thin flange tyres/wheels considerable amount of sound material is lost in restoring the flange profile by machining. Some experimental work has been carried out on carriage and wagon tyres for building up the worn out portions using submerged arc process. Apart from considerable saving in cost, the process would also conserve steel substantially by reducing the requirement of tyres by the Railways. Necessary investigations for standardisation of the technique for reclamation of such worn out wheels is being taken up.

6.10 Production of steel.

6.10.1 Special quality steels.

For achieving maximum economy in consumption of steel, it would be necessary to develop facilities in the country for production of special quality steels, of the following types:

(a) Plates and structurals to IS:2062-1969. This will enable introduction of welded construction in railway bridge girders and wagon construction.

(b) High strength deformed bars of proof stress upto 60 kg/sq.mm (either hot or cold rolled). This will be used for reinforcement in RC with considerable reduction in consumption of steel.

(c) High tensile steel to IS: 961-1962 with copper bearing quality. These can be used in bridge girders of long spans.

(d) Low alloy high strength steels. These will be required for wagons and coach construction being corrosion resistant.

(e) Weathering steel. For use in bridge girders, multistoreyed buildings and very high towers.

(f) High tensile steel of weldable quality having proof stress of 70 to 80 kg/sq.mm for use in bridge girders.

6.10.2 Parallel flange sections.

Parallel flange beams are more efficient in use of steel compared to sloping flange sections. In the interest of economy in consumption of steel, it is desirable that India should manufacture parallel flange beams as early as possible. The facilities for the purpose are to be augmented in the existing plants and they have to be planned immediately so that in the course of a few years, we can switch over to manufacture of these sections and gradually taper down the production of sloping flange beams. Installation of universal mills in new steel plants will have to be a part of this programme. ISI may prepare necessary standards for parallel flange sections on the lines of ISO Standards.

6.10.3 Setting up of plants for automatic fabrication of structural forms.

The Working Group No.II under the Wanchoo Committee had recommended setting up of six plants for the fabrication of structural forms in a phased manner. The intention is to produce continuously welded beams upto 2 m deep in the steel plants and make them available in the market, keeping in view the limitations on the maximum depth of rolled sections. These continuous welded beams will make use of plates. It is considered necessary for Steel Ministry to pursue this project of setting up of the six plants as and when the production of plates is increased and the country becomes self-sufficient in plates.

6.10.4 Increase in the number of rationalised sections

Although the ISI has prescribed an exhaustive list of structural sections, plates, sheets and bars, the steel manufacturers do not produce all these items. A statement showing the total number of sections indicated in the Indian Standard and the number of sections rationalised by JPC is shown below:

Table V

Type of section	No. of sections as per IS Hand Book No.1	No. of rationalised sections.*	Percentage of 3 to 2
1	2	3	4
Beams	79	16	20.3
Channels	46	19	41.4
Equal angle	72	34	47.2
Unequal angle	65	14	21.6
Tee	23	1	4.4
Plates	(625 + 3) = 628	127	20.0
Rounds	(33 + 6) = 39	29	74.5
Flats	(210 +14) = 224	16	7.2
	1176	256	21.8

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* Based on JPC Booklet of April, 1973.

The number of rationalised items form a small percentage of the total number of sections standardised. Recently, there has been a move from the Iron & Steel Controller to further reduce these rationalised sections. If all the sections shown in the Indian Standards become available, a designer has a greater choice in selecting a section nearest to the one required according to the design calculations. With the present shortage of the number of sections, a designer has to necessarily go in for a heavier section than is warranted by design calculations.

The difficulty faced by the producers is that if all the sections indicated in the Indian Standards are to be produced, the production capacity will fall. A judicious compromise between the requirements of the designers for economy in the weight of structures and the possibility of production by the manufacturers without a considerable fall in the output may have to be worked out.

Another difficulty faced by designers and users is that even when sizes indicated in the list of rationalised sections are shown in the drawing, they are also not available. The number of sections actually manufactured is even for less than that rationalised. There are a few rationalised structural sections which are not to any Indian Standard. This is not desirable and their manufacture should be stopped, or if they are found efficient in the use of steel, they could be incorporated in the Indian Standard. To start with, it is suggested that the producers should arrange to roll at least all the IS sections rationalised. In course of time when the production capacity in the steel plants increases, the number of sections rationalised should increase progressively so that all the sections shown in the Indian Standard are manufactured in the country. This review may be undertaken by JPC in consultation with ISI and major users periodically.

6.10.5 Availability of plates in required lengths.

Another problem that has recently been presented by the manufacturers is the maximum length of the plates that can be produced by them. Till recently, plates in lengths upto 13.5m used to be rolled and supplied to meet the special requirements of the Railways. Now the maximum length proposed is 10 m only for plates of 12 mm and below and 12.5 m for plates above 12 mm. Here again, the considerations appear to have been based on the billet and bloom. In the absence of getting plates of the required lengths, splice joints are to be introduced even in 12.2m span plate girders and in diagonals of a number of open web girders in Railways leading to increased consumption of steel. Efforts may be made by the Steel Plants to supply plates in lengths upto 13.5 m to meet the special requirements of Railways and other organisations, as far as possible.

6.10.6 Tolerances in length of finished steel products.

The present cutting tolerances in length prescribed in IS:1852, viz., +75mm and -25mm for the finished steel products are very liberal. Most of the foreign countries have very fine tolerances. There is a proposal under consideration by International Standards Organisation to mention the tolerances in length under three groups, viz., on stock length, on specified length and on exact length. In the last category, tolerances will be only +3mm and -0. As soon as ISO adopts these proposals, ISI will also automatically adopt them. Such reduced tolerances reduce the wastage of steel and in the interest of economy, it is necessary to prescribe tight cutting tolerances. The present practice in Indian Mills of hot shearing renders achieving such fine tolerance difficult. Sophisticated automatic hot/cold sawing equipment will have to be progressively introduced in the steel plants with a view to achieving this objective of reducing the cutting tolerances.

6.10.7 Continuous casting of steel.

Continuous casting has become one of the most broadly applicable of the many cost saving innovations of modern steel making operations. The main metallurgical advantages of continuous casting process are: (a) a better quality of cast product because of greater homogeneity, less segregation, a finer grain primary structure and in the case of hard steels a more homogeneous distribution of carbides; (b) a reduction in amount of hot working; and (c) an increase in the yield of sound metal because of considerable reduction in top and bottom discards.

The yield of continuous cast steel is of a very high order (about 90 to 96 per cent) compared to conventional steel making process (an average 70-75 per cent with top and bottom discard). Therefore, increased use of continuously cast steel wherever possible will effect economy.

6.10.8 Oil quenching and tempering of wheel tyres.

As per the stipulation in IRS R15-64-specification for steel tyres for locomotives, carriages and wagons and EMU coaches are of high tensile grade which are required to be oil quenched and tempered. There is not sufficient facility for oil quenching and tempering of the tyres in the country. Other methods, viz., rim quenching and improved rim quenching are in vogue. Trials carried out by TISCO on EMU coach tyres have not proved to be very satisfactory. In the process of hardening by rim quenching only a certain portion of the material gets hardened and tempered with higher wear resisting quality. Thorough hardening of tyres for better serviceability is a must and it is felt that if oil quenching and tempering facilities are set up in the country, the requirement of tyres of steam loco and EMU coaches per annum will be reduced as the tyres so produced will have better service life. Thus setting up of such facilities in the country would ultimately effect economy in steel consumption in respect of loco and EMU tyres in the country.

6.10.9 Rails.

The Ministry of Steel in consultation with the Ministry of Railways may arrange for development of wear-resistant rails such as UIC grade 'B'/grade 'A' and also chrome manganese steel rails. UIC grade 'B' rails have already been produced by HSL. The other two forms of rails are still to be developed. Depending upon the service trials on these rails, production of a suitable wear resistant rail may be undertaken. There is also need for development and production of suitable corrosion-resistant rail and volume-hardened rail, to derive maximum service life out of the rails. Ministries of Steel and Railways may take action in this regard as well.

6.10.10 Crane rails.

IS:3443-66 gives the specification and profile of crane rails CR-50, CR-60, CR-80, CR-100 and CR-140. At present only 2 of these sections, viz., CR-80 and CR-100 are rolled in Bhilai Steel Plant while a non-standard 135 lb section is rolled by TISCO. It is understood that because other crane rail sections are not being developed in the country by the prime producers, crane rails are to be imported particularly for steel plant structures. Although the quantity of crane rails consumed in the country may not be considerable, the Committee is of the opinion that development of all the crane rail sections shown in Indian Standard as a long-term proposal is desirable in the interest of conserving foreign exchange.

6.11 Timber production and distribution.

The primary species of timber such as teak, deodar, sal, etc., which possess the inherent strength and also durability for which they are prized, are in limited supply. However, species of timber which are fit for structural utilisation, having the intrinsic strength, though not the expected durability are available in comparatively large quantities in the country. If such species are suitably seasoned and given proper wood preservation treatment, they could also be used for building construction, in place of steel and also the high grade wood. Further, the available resources of the high grade woods could be extended by means of utilising them only for permanent buildings, i.e., in other words, random utilisation of high grade woods, where the secondary species would be good enough, could also be done away with. Although wood seasoning and treatment plants have been set up in various parts of the country, concomitant developments required for supply of timber and scientific methods of conversion and utilisation of timbers from logs are yet to come to satisfactory levels.

It may be mentioned that forests in the country have been "nationalised", and are under the control of the respective State Governments. Corporations for processing and marketing timber have, however, been formed only in some States such as Orissa, Madhya Pradesh, Rajasthan, Maharashtra and Karnataka. Supply and distribution of a substantial quantity of timber in a number of States is still in the hands of small traders and saw millers. Without planned scientific methods of conversion of sawn timber from logs, there is wastage of raw material, which can be avoided. It is recommended that the remaining States also may consider setting up Corporations so that technically acceptable material may be made available everywhere.

6.12 Production of other materials.

The advantages of use in various civil engineering and other structures of substitute materials like light weight aggregate made out of expanded clay, concrete-polymer composite, fibreglass for reinforcement in RC and wagon industry, structural aluminium alloy to replace steel in a number of items, high strength cables for cable-stayed structures, rubber springs, etc., have already been brought out. It is recommended that the Ministry of Industrial Development may undertake a detailed study for the development and production of these materials. In regard to a plant for light weight aggregate, NBO have already prepared a feasibility report for its establishment, after large scale test evaluation of Palta Water Works silt at Calcutta. They have suggested that light weight aggregate plants should be established at Calcutta, Lucknow and in Tripura at the first instance. This also requires to be pursued.

6.13 Conclusion.

As pointed out in Chapter V, estimation of the total quantity of steel that could be saved with the implementation of the recommendations of the Committee is rather difficult. However, reduction in consumption that could be achieved with the implementation of the short-term proposals were roughly assessed in a modest way and indicated in para 5.13.1. A similar assessment made with regard to the full implementation of all the long-term proposals contained in this chapter reveals that an additional saving to the tune of 2,80,000 tonnes at the present level of consumption of steel in the country can be anticipated, vide details given below:

Table VI

S.No.	Type of work	Present level of consumption of steel (tonnes	Percentage saving	Reduction in consumption anticipated (tonnes)
1	2	3	4	5
1.	Structural light weight concrete.	1,00,000	10	10,000
2.	Welding of reinforcement bars.	9,00,000	3	27,000
3.	Structural fabrication.	4,20,000	5	21,000
4.	Bridges	40,000	25	10,000
5.	Railway track	(see para 6.5.1.8)		60,000
6.	Railway wagon manufacture	1,20,000	10	12,000
7.	Railway coach manufacture	50,000	5	2,500
** 8.	Use of timber-secondary species.	5,00,000	25	1,25,000
9.	Miscellaneous			12,500
				2,80,000

** The annual output of secondary species of timber is about a million tonnes, out of which approximately 50 per cent may become available for replacing steel structures. The weight of steel substituted will be about 25 per cent of the weight of timber.

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CHAPTER VII

SUGGESTIONS FOR IMPLEMENTATION OF THE RECOMMENDATIONS

7.0 General.

Most of the ideas leading to economy in consumption of steel, particularly in civil engineering construction are only too well-known. The main bottleneck has been with regard to bringing these ideas into practice. A few Committees/organisations who had gone into this question during the last 20 years had made a number of useful recommendations earlier. The Committee feels that several of the earlier recommendations have not been given effect to and therefore, the benefits have not been realised. Some of the important items yet to be implemented have been dealt with in para 3.7. This subject has, therefore, received the special attention of this Committee. However, while making suggestions for implementation of the recommendations, constitution of new broad-based bodies either at the Central level or State level or local level is not likely to be effective. The existing controlling and regulatory bodies in the Central and State Governments and the local bodies should undertake the responsibility of ensuring that the recommendations of this Committee are given effect to. It is possible that in some cases, the existing machinery is either not competent or is not adequate to ensure this. In such cases, it is worthwhile strengthening the set up to make it competent and adequate.

The only two new bodies visualised are the high level Cell directly under the Minister of Steel and Mines and the other Special Cell in the I.S.I. referred to in paras 7.1 and 7.3, respectively. The former will keep in touch with various Ministries and State Governments in respect of extent of implementation of the recommendations and keep the Minister of Steel and Mines advised periodically. The function of this Cell will be purely one of monitoring and enabling the Minister of Steel and Mines to use his good offices. The Cell in the I.S.I. will undertake the technical functions described in para 7.3.

It is emphasized that the existing manufacturers of steel, designers, fabricators and users should be made aware of the national importance of avoiding improper use of and misuse of steel of which there is short supply in the country. Two to three hundred crores of rupees are spent annually in foreign exchange for import of steel. By avoiding this foreign exchange outgo, it might be possible to set up a new steel plant every year in the country.

7.1 Steel Economy Cell.

The Committee considers that setting up of a wholetime organisation to monitor the implementation of the recommendations is an absolute necessity, if the recommendations made by this Committee are to be effectively implemented. This could be designated as "Steel Economy Cell", which will report to and work directly under the Minister of Steel and Mines. The Steel Economy Cell should be headed by a competent person who has extensive experience of use of steel. The scope of work to be dealt with by this Cell will be as under:

a) Co-ordinate with Central Government Ministries and Departments and the State Governments to ensure that instructions are issued by them adopting the recommendations made by the Committee.

b) Pursue with the Ministries of Industrial Development, Planning, Agriculture, Works and Housing, Railways, etc., for development and production of substitute materials recommended by the Committee.

c) Co-ordinate with the Ministry of Steel and Mines for change in the pattern of production in the existing steel plants.

d) Maintain liaison with JPC to ensure that the planning and production pattern of steel are in line with the recommendations of the Committee and to ensure progressive increase in the number of rationalised sections

e) Maintain liaison with ISI for periodical [illegible] of codes and specifications pertaining to steel economy.

f) Maintain liaison with the Special Cell under I.S.I. (mentioned in para 7.3) for preparation and issue of hand-books and other design aids.

g) Scrutinise applications for awards for making outstanding contributions to economising in consumption of steel and make recommendations

h) Maintain liaison with the State Governments to ensure that the building bye-laws are amended by local bodies incorporating the recommendations of the Committee.

i) Keep Minister of Steel and Mines advised periodically the extent of implementation of the recommendations.

7.2 Issue of instructions by Government.

The means of achieving economy suggested in the Report include adoption of improved design methods and construction practices, change in the production pattern in the existing steel plants and for development and manufacture of new steel materials and other substitute materials. These cover the fields of all civil engineering works including highway and railway bridge constructions and design and manufacture of railway coaches and wagons. Instructions are, therefore, required to be issued by several departments of the Central Government and by all the State Governments and local bodies adopting these recommendations. Follow up action is also to be pursued by them. Building bye-laws of Municipal Corporations and other local bodies are to be modified in the light of the recommendations made by the Committee and these are to be ensured by the State Governments.

The officers and staff manning the Bridge and Structural Design Wings in the Central and State Governments should be encouraged to undergo refresher courses and specialised in-service training so that they are upto-date in the knowledge of bridge and structural engineering practices in the country and abroad. This will enable modern concepts in the designs of bridges and structures being introduced instead of following the conventional designs and age-old practices. This will ultimately lead to economy in the cost of construction, besides economical and efficient use of steel.

The departments of Central and State Governments and other administrations responsible for constructional activities and for their approval may, as far as possible, adopt the I.S. design codes for buildings and structures without any relaxation, unless special circumstances warrant such deviation.

7.3 Special Cell in I.S.I.

It is also necessary to prepare and supply free of cost, design aids in the form of hand-books, typical designs, monograms, charts, tables, etc., explaining the modern design practices in civil engineering construction which will lead to economy in consumption of steel. Dissemination of the knowledge to the architects will also be part of this programme. A wholetime Special Cell will have to be constituted under I.S.I. to undertake this work. Since the preparation of these hand-books and other design aids will need the assistance of specialists in different fields, the Special Cell in the I.S.I. could be manned by specialists drawn on deputation from different Ministries and Public and Private Sectors. Unless preparation of handbooks and design aids is entrusted as a wholetime job to specialists, instead of the present method followed by I.S.I. of having this work done through organisations who have their own works to do, their preparation and finalisation are likely to be delayed. Handbooks, design aids, etc., should be supplied not only to practising civil engineers and architects but also to final-year Civil Engineering students in all Engineering Colleges. Teachers and students of Engineering Colleges may be exposed to the latest changes made in the design Codes by special lectures, to make them aware of the upto-date concepts introduced in Codes.

7.4 Certificate by authority approving works.

With the amendment of bye-laws by local bodies, it should be possible for the Municipal Engineer to ensure that while any construction work is approved, the recommendations of this Committee are fully complied with and that the requirement of steel has been kept to the minimum. In the case of works undertaken by Government organisations, this should be ensured by the technical officers competent to sanction the estimates and approve the designs. Certificates to this effect should be recorded by the Municipal Engineers/the sanctioning authority, while giving approval. Suitable instructions are to be issued by the different Government Departments for this purpose.

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7.5 Awards and titles.

Institutions, structural designers, research scholars, scientists, manufacturing units, etc., who have done outstanding work and made significant contribution in regard to economy in consumption of steel in the country may be considered for national awards and titles.

7.6 Increase in cost of buildings/structures.

Since the recommendations for economy in consumption of steel made by the Committee may not mean a corresponding reduction in cost of the structure, instructions are to be issued by the different Government departments permitting increase in cost of work, if such increase is on account of implementing the recommendations made by this Committee.

7.7 Financial implications.

The scope for economising in use of steel as visualised in this Report is considerable. Therefore, there should be no stinting in expenditure in setting up the Steel Economy Cell under the Minister of Steel and Mines and

Special Cell in I.S.I. in respect of the level of expertise and adequacy of strength of the two Cells. The expenditure that will be incurred in printing the design aids and distributing them free will be fully justified. The overall expenditure on implementating the recommendations of the Committee will be amply compensated by saving in steel and reduction in import of steel.

7.8 Steel Economy Committees.

Steel Economy Committees may be constituted by the Government of India periodically, say once in 5 years or so, to review the extent of implementation of the recommendations of the earlier Committee and the benefits therefrom and also to bring the earlier recommendations upto-date taking into consideration the latest concepts in rational and efficient use of steel and their production.

7.9 Conclusion.

Much good work was done by earlier Committees in studying the problems connected with conservation of steel. But unfortunately the follow-up action does not appear to have been adequate. This Committee hopes that government will take dynamic steps not only to issue instructions but also to see that the instructions are followed. If the recommendations are implemented fully, their is no doubt that an enormous quantity of steel can be conserved and the annual outgo of foreign exchange much reduced, if not totally eliminated. The Committee would then feel amply rewarded for its labours.

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ANNEXURES

ANNEXURE I.

PRODUCTION OF FINISHED STEEL BY CATEGORIES DURING 1970-71, 1971-72, AND 1972-73.

(in '000 tonnes)

Categories	1970-71	1971-72	1972-73
Structurals, Light & Medium	641.7	512.0	645.6
Structurals, Heavy	238.3	192.9	208.1
Rails: i) 1st class	243.7	259.7	262.7
ii) 2nd class	145.4	109.6	60.1
Rails light	5.5	6.4	3.9
Black sheet Plain (i) HR	212.4	219.1	230.4
(ii) CR	85.2	96.1	96.2
Black sheet Corrugated	-	0.7	0.3
Galvanised sheet plain	72.9	57.7	70.6
Galvanised sheet corrugated	117.2	108.9	92.9
Plates	271.4	274.9	313.1
Hoops	6.6	8.2	7.9
Strips: (i) HR	91.6	105.6	141.3
(ii) CR	100.1	102.5	100.3
Box strappings	6.7	5.1	2.8
Tinplates	133.4	114.5	116.1
Bars	1055.7	1153.8	1309.1
Rods	517.6	562.8	711.5
Wires Black	48.5	81.2	95.5
Wires galvanised	34.8	52.1	57.6
Wires others	52.3	90.9	89.3
Wheels, Tyres & Axles	37.5	32.0	30.4
Steel sleepers	58,8	67.7	87.4
Skelp	242.6	232.7	247.7
Special sections	57.5	75.4	53.1
Tool, alloy & special steel	350.0	264.8	234.6
Total	4827.4	4787.3	5268.5

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NB: 1972-73 figures are provisional.

Source: All India Iron & Steel Statistical Data.

ANNEXURE II

Imports of iron and steel materials and ferro alloys during 1970-71, 1971-72 and 1972-73 (upto December 1972).

(Quantity in metric tonnes and value in lakhs rupees)

Category	1970-71		1971-72		1972-73	
	Quantity	Value	Quantity	Value	Quantity	Value
A. Pig iron, sponge iron, steel powder and shot ferro alloys.	630	10	704	13	417	9
B. Ferro alloys.	979	190	7,436	285	1,540	60
C. Mild steel.						
1. Ingots and other primary forms.	264	10	1,118	23	191	8
2. Blooms, billets and slabs.	24,015	345	109,731	1,082	63,664	539
3. Structurals.	8,197	139	27,219	355	42,619	539
4. Tinned plate sheets.	48,989	698	64,197	1,035	39,174	621
5. Plates.	189,277	2,940	428,947	5,741	243,943	3,313
6. Sheets.	190,413	3,529	235,557	3,797	248,632	3,465
7. Wire.	4,354	122	13,738	336	3,589	100
8. M.S.Wire rod.	5,768	106	28,258	432	19,157	265
9. Bars and rods.	25,145	453	41,921	678	15,299	245
10. Hoops and strips.	17,618	376	82,481	1,137	21,895	345
11. Rails and railway track construction.	655	18	92	3	2	-
12. Wheels, tyres and axles.	5,513	134	20,172	547	5,503	186
Sub-total: Mild steel:	520,208	8,870	1053,431	15,166	703,668	9,626
D. Tool, alloy and special steel.	132,951	3,993	260,348	6,664	183,504	4,395
E. Scraps.	8,400	91	18,250	179	7,386	77
F. Castings and forgings.	9,077	474	7,014	439	4,904	372
Total:	672,245	13,628	1347,183	22,746	901,419	14,539

Source:- All India Iron and Steel Statistical Data.

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ANNEXURE III

Exports of iron and steel materials and ferro-alloys during 1970-71, 1971-72 and 1972-73 (upto December 1972).

(Quantity in metric tonnes and value in lakhs rupees)

Category	1970-71		1971-72		1972-73	
	Quantity	Value	Quantity	Value	Quantity	Value
A. Pig Iron, sponge iron steel powder and shot ferro alloys.	502,115	2,278	203,665	681	238,578	796
B. Ferro alloys.	98,617	1,139	21,992	298	50,956	448
C. Mild steel:						
1. Ingots and other primary forms.	29,082	129	-	-	-	-
2. Blooms, billets and slabs.	29,115	165	411	3	6,573	56
3. Structurals.	231,911	2,251	99,604	894	44,943	403
4. Tinned plate sheets.	84	2	-	-	3	-
5. Plates.	2,034	22	320	4	33	1
6. Sheets.	754	9	361	5	3,258	43
7. Wire.	758	13	975	18	110	3
8. M.S. wire rod.	10,895	89	257	4	1,708	22
9. Bars and rods.	124,169	1,095	13,904	129	14,943	156
10. Hoops and strips.	152	2	-	-	4	-
11. Rails and railway track construction material.	85,018	652	96,297	882	11,790	116
12. Wheels, tyres and axles.	60	3	-	-	-	-
Sub-total: Mild steel:-	514,032	4,432	212,129	1,939	83,365	800
D. Tool alloy and special steel.	13,660	127	6,462	56	2,379	25
E. Scraps.	260,905	695	146,028	199	53,177	85
F. Castings and forgings.	1,439	23	1,330	29	644	12
Total:-	1,390,768	8,694	591,606	3,202	429,099	2,166

Source: All India Iron and Steel Statistical Data.

ANNEXURE IV

Despatches of Finished Steel under broad quota heads of various States during 1972-73 by the main steel producers.

(In '000 tonnes)

Name of State.	Govt. consumers (Excl. Rly.)	Non-Govt. consumers.	SSIC/SSI units	Trade	Producer stockist	Unclassified	Total
1. Andhra Pradesh.	49.4	26.7	18.4	3.0	22.9	1.2	121.6
2. Assam	18.5	9.0	3.7	1.6	12.3	0.1	45.2
3. Bihar	110.1	153.2	6.6	1.4	23.0	1.6	295.9
4. Delhi	29.9	22.7	12.4	3.2	67.5	2.2	137.9
5. Goa	3.5	1.5	0.6	-	-	-	5.6
6. Gujarat	34.8	52.2	18.6	2.4	32.7	1.3	142.0
7. Haryana	16.2	61.6	27.9	0.6	-	1.9	108.2
8. Himachal Pradesh.	3.4	0.2	4.3	-	-	-	7.9
9. Jammu & Kashmir.	12.8	1.8	3.0	2.0	5.4	-	25.0
10. Kerala	21.3	8.6	3.2	0.8	13.9	0.2	48.0
11. Madhya Pradesh.	104.9	19.3	14.5	1.3	19.0	0.4	159.4
12. Maharashtra.	87.3	181.8	67.6	8.8	79.1	6.8	431.4
13. Manipore.	4.5	-	-	-	-	-	4.5
14. Mysore.	21.8	8.8	12.2	0.9	15.9	0.7	60.3
15. Nagaland.	9.8	0.1	0.1	-	-	-	10.0
16. N.E.F.A.	0.7	-	-	-	-	-	0.7
17. Orissa.	43.8	23.3	4.3	1.3	12.4	0.3	85.4
18. Pondichery.	0.1	1.0	0.2	-	-	-	1.3
19. Punjab.	44.4	42.5	58.5	5.6	37.4	3.5	191.9
20. Rajasthan.	18.7	33.3	10.7	2.5	8.4	2.5	76.1
21. Tamil Nadu.	54.8	57.9	13.9	4.0	42.2	1.8	174.6
22. Tripura.	2.1	-	0.4	0.1	-	-	2.6
23. Uttar Pradesh.	102.8	52.5	38.4	9.2	52.2	4.7	259.8
24. West Bengal.	69.7	223.7	67.3	8.7	56.3	13.5	439.2
Total:	865.3	981.7	386.8	57.4	500.6	42.7	2834.5
Railways:	-	-	-	-	-	-	402.0
Grand Total:							3236.5

N.B :- (1) "Unclassified" represents despatches made against orders carrying no "Quota" classification.
(2) Based on revised figures received from Joint Plant Committee.
(3) Figures are provisional.

Source: All India Iron & Steel Statistical Data.
